THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. II.

No. III.—MARCH, 1905.

ORIGINAL ARTICLES.

I.—Sedgwick Museum Notes.

New Fossils from the Haverfordwest District. III.

By F. R. Cowper Reed, M.A., F.G.S.

(PLATE IV.)

Family HARPEDIDÆ.

Harpes sp. (Pl. IV, Fig. 1.)

In Mr. Turnbull's collection from the Sholeshook Limestone of the Sholeshook Railway Cutting there is a small but perfect 'horse-shoe' limb of a species of *Harpes*—a genus which has not been previously recorded from this bed. The 'horse-shoe' is oval and rather elongate, and narrow in proportion to its length; the arms curve inwards gently, so that their acutely pointed posterior extremities are approximate. There seems to be a marginal, single row of large pits round the outer edge of the flattened limb, but the general surface is covered with very minute punctæ. The inner edge of the limb is not well preserved. The arms extend backwards to about twice the length of the head-shield.

Dimensions.	mm.
Width of horse-shoe	7
Length of ditto	11
Width of arms	3

Remarks.—This form has a more elongate horse-shoe, with the arms more curved inwards, than *H. Wegelini*, Angelin,[1] but this difference in shape may be more or less due to slight distortion in our specimen.

The genus is perhaps represented also in the Slade Beds.

Family TRINUCLEIDÆ.

Ampyx cf. rostratus, Sars. (Pl. IV, Fig. 2.)

It is not absolutely certain if the species *A. rostratus*, Sars,[2] really occurs in the British Isles, though it has frequently been quoted.

[1] Schmidt: Rev. Ostbalt. Silur. Trilob., Abth. iv (1894), p. 69, t. v, figs. 10–18.
[2] Sars: in *Isis* (1835), p. 334, t. viii, figs. *3a–c*.

The author has seen reasons for removing the Girvan trilobites previously referred to this species into another and new species;[1] but there is a specimen of a head-shield in Mr. Turnbull's collection from the Slade Beds of Upper Slade which bears a very close resemblance to the foreign form. The carination of the glabella is strong, and the cheeks only extend about half-way up its sides. The frontal spine, the relative proportions and shape of the various parts of the head-shield seem to be absolutely identical with what we know of *A. rostratus*. *A. tumidus*, Forbes, has been recorded by Messrs. Marr & Roberts[2] from the Sholeshook Limestone of the Haverfordwest district.

Family OLENIDÆ.

Remopleurides Salteri, Reed, var. (Pl. IV, Fig. 3.)

Messrs. Marr & Roberts (op. cit., p. 481) recorded *Remopleurides radians*, Barr., from the Sholeshook Limestone.

There are examples of a species of this genus from the Slade Beds of the quarry at Upper Slade which cannot be referred to the same species, as they possess only two pairs of lateral furrows on the glabella, and the latter has a relatively much broader anterior tongue and is finely tuberculated round its posterior lateral margins. In these characters, as well as in its general shape and tuberculated neck-ring with serrated margin, it resembles *R. Salteri*, var. *girvanensis*, Reed,[3] and though the Slade specimens are too poorly preserved to identify them positively with this variety, yet I have no hesitation in ascribing it to the same species. The true *R. radians*, Barrande, is quite distinct, as I have verified by comparison with Bohemian examples of it.

Family PROETIDÆ.

Cyphaspis megalops (McCoy).

This species was recorded by Messrs. Marr & Roberts[4] from the Sholeshook Limestone, but Mr. Turnbull has collected a good head-shield from the Slade Beds near St. Martin's Cemetery, Haverfordwest.

Cyphaspis cf. Harknessi, Reed.

An imperfect head-shield, but showing the characters of the glabella clearly, was collected by Mr. H. Kynaston (now Director of the Transvaal Geological Survey) from the Slade Beds of West Pelcomb. It is comparable with the species described by the author[5] as *Cyphaspis* (?) *Harknessi* from the Keisley Limestone. The length of the glabella is about 8 mm., and its basal width is about the same.

[1] Reed: Lower Palæozoic Trilobites of the Girvan District (Palæont. Soc.), pt. i (1903), p. 18.
[2] Marr & Roberts: Q.J.G.S., vol. xli (1885), p. 481.
[3] Reed: Lower Palæoz. Trilob. Girvan District, pt. i (1903), p. 39, pl. vi, figs. 8–15.
[4] Marr & Roberts: Q.J.G.S., vol. xli (1885), p. 481.
[5] Reed: Q.J.G.S., vol. lii (1896), p. 435, pl. xxi, fig. 2.

Family ACIDASPIDÆ.

Acidaspis (Ceratocephala) Turnbulli, sp. nov.

(Pl. IV, Figs. 4–7.)

There are several specimens in the Sedgwick Museum of a species of *Acidaspis* from the Sholeshook Limestone of the Haverfordwest district, which, though imperfect, afford sufficient evidence to recognise in them a new species. In one example the entire individual is preserved with the exception of about half the thorax and pygidium. The head-shield is not complete and is somewhat crushed, but with the aid of another specimen exhibiting some of the missing features more perfectly, a fairly full description can be given.

Description.—General form broadly ovate. Head-shield large, semicircular, moderately convex. Glabella oval or subcylindrical; median lobe convex, cylindrical, nearly parallel-sided, slightly expanded at front end so as to overhang the lateral lobes. Two pairs of lateral lobes present; the anterior pair small, elongate, obliquely oval; the posterior pair about twice the length of the anterior pair, narrow, elongate, pointed anteriorly, extending about half the length of the glabella. First lateral furrows strong, curving at first inwards and then running parallel backwards to the occipital furrows, thus completely separating median from lateral lobes of glabella. Second lateral furrows weak, oblique. Axial furrows arched gently outwards, increasing in depth posteriorly. Occipital furrow distinct, broad. Occipital ring broad, prominent, rounded, furnished with large median tubercle and pair of low, obscurely marked transverse occipital lobes; margin of ring provided with a pair of short, stout, subparallel spines. Fixed cheeks swollen, curved, elongated. Ocular ridge narrow, rounded. Surface of head-shield tuberculate, with a few scattered tubercles of larger size. (Pl. IV, Fig. 5.)

Thorax of nine segments; about $1\frac{1}{2}$ times the length of head-shield. Axis narrow, strongly convex, prominent; axial rings furnished with distinct lateral nodular swellings. Pleuræ straight, horizontally extended at right angles to axis, each bearing a submedian broad elevated ridge with a narrow anterior border separated from it by a broad but shallow furrow, and a narrow posterior marginal band; ridge of pleuræ bears two prominent tubercles regularly placed at the same distance from the axis all down the thorax; extremities of pleuræ produced into two spines, an anterior short one and a posterior longer curved one with a tubercle at its base. (Fig. 6.) Pygidium (imperfectly known) broadly semicircular; axis (not well preserved) convex, prominent; lateral lobes flat, horizontally extended, with margin furnished with five or six pairs of long, slightly curved spines of equal size (the points are broken off in the specimen); surface of lateral lobes marked by three subparallel rounded pleural ridges, the middle one being the largest; the first ridge runs to the base of the third marginal spine, the middle one from the first axial ring to the base of the fourth, and the posterior and faintest one to the base of the fifth. (Fig. 7.)

DIMENSIONS.

	mm.
Length	29
Length of head	10
Length of thorax	14
Width of thorax	20

AFFINITIES.—The glabella of this species appears to bear a considerable resemblance to *A. callipareos*, Wyv. Thomson.[1] Double spines to the extremities of the pleuræ are found in the Bala species *A. Caractaci*, Salter,[2] and the pygidium is somewhat similar to this species, but the marginal spines are unequal in strength, and the head-shield is completely different. *A. evoluta*, Törnquist,[3] from the Leptæna Limestone, of which only the head-shield has been described, possesses a somewhat similar lobation of the glabella with a broad occipital ring and occipital lobes. *A. Jamesi*, Salter,[4] and *A. bispinosus*, McCoy,[5] two well-characterised British Ordovician forms, are quite distinct, save for the separation of the median lobe of the glabella and the pair of short occipital spines.

Note.—This new species appears also to be represented in the Slade Beds, from which Mr. Turnbull has recently obtained some specimens.

ACIDASPIS (CERATOCEPHALA) SLADENSIS, sp. nov.

(Pl. IV, Figs. 8–12.)

Another and smaller species of *Acidaspis* occurs in the Slade Beds; only the head-shield and the pygidium are known, but the specimens are nearly complete and in a good state of preservation.

DESCRIPTION. — Head-shield semicircular, moderately convex. Glabella oval, nearly as wide as long; median lobe convex, cylindrical, fairly well marked off from the lateral lobes, expanded a little in front, gently rounded or subtruncate anteriorly. Anterior pair of lateral lobes oval, convex, less than one-third the length of glabella; posterior pair oval, convex, nearly twice as large as anterior pair, not strongly marked off from them. First pair of lateral furrows short, curved back to meet second pair; second pair weak between lateral lobes, but continued backwards more strongly along inner side of second lateral lobes to enter occipital furrow. Occipital furrow strong, wide, horizontal; occipital ring broad, nearly one-third the length of glabella, provided with large median tubercle and obscure traces of small occipital lobes; margin furnished laterally with pair of posteriorly directed divergent long spines. Axial furrows distinct, arched outwards. Fixed cheeks swollen, curved, widening posteriorly to nearly the width of glabella. Ocular ridge narrow, raised, rounded. Eyes small, situated wide apart, and far

[1] Wyville Thomson: Q.J.G.S., vol. xiii (1857), p. 208, pl. vi, figs. 11, 12.
[2] Salter: ibid., p. 211, pl. vi, figs. 15–17.
[3] Törnquist: Undersokn. Siljans. Trilobitf. (1884), p. 28, t. i, fig. 21.
[4] Salter: Mem. Geol. Surv., dec. vii (1853), pl. vi, figs. 1, 2, 3.
[5] Salter: ibid., p. 4, pl. vi, fig. 4.

back, nearly opposite middle of posterior lateral lobes. Neck segment rounded, narrow, widening laterally, marked off from fixed cheeks by strong furrow. Facial sutures cut posterior margin of head-shield far out. Anterior margin of head-shield provided with narrow raised rounded border with strong marginal furrow. Surface of head-shield coarsely tuberculated. Thorax unknown.

Pygidium broadly semicircular, transversely expanded, almost flat; posterior margin furnished with seven pairs of equidistant short radiating spines of equal length and size. Axis convex, short, bluntly terminating inside narrow raised rim, not quite one-third the width of the pygidium, composed of two segments and of a small articulating ring in front; first segment formed by a complete rounded ring; second segment broader and bearing a median pair of large tubercles and a lateral pair of smaller ones. Lateral lobes flat, horizontally extended without definite pleural ridges, but with 2–3 large elongated tubercles. Marginal rim raised, rounded, narrow, with regular double row of tubercles. Marginal spines granulated. (Pl. IV, Figs. 11, 12.)

DIMENSIONS.

	mm.
Length of head-shield	3·0
Length of pygidium (without spines)	1·5
Width of ditto	4·0

AFFINITIES.—This species has many of the characters of *A. Lalage*, Wyv. Thomson,[1] particularly in the lobation of the glabella and occipital spines, but it differs in the coarse tuberculation of the head-shield and in the features of the pygidium. The pygidium, indeed, more resembles that of *A. hystrix*, Wyv. Thomson,[2] but the latter has distinct pleural ridges on the lateral lobes, and no pair of conspicuous tubercles on the second axial segment. *A. Grayæ*, Etheridge,[3] is too imperfectly known, but the pygidium is certainly distinct.

Both these species, *A. sladensis* and *A. Turnbulli*, belong to the subgenus *Ceratocephala*, Warder, 1838 (type *C. goniata*, Warder), as understood and limited by Clarke.[4] Van Ingen[5] suggests using the divisional names *Odontopleura*, *Selenopeltis*, *Ceratocephala*, *Dicranurus*, *Acidaspis*, and *Ancyropyge* in a generic sense, but this does not seem desirable, as the value of these groups is scarcely of so high a rank.

Family LICHADIDÆ.

LICHAS (METOPOLICHAS) AFFINIS, Angelin, var.

(Pl. IV, Fig. 13.)

There is one fairly well-preserved pygidium of a species of *Lichas* from the Slade Beds which cannot be referred to any common British

[1] Nicholson & Etheridge: Mon. Foss. Girvan, fasc. i (1878), p. 121, pl. viii, figs. 20–22 (*non* figs. 17–19).
[2] Ibid., p. 123, pl. viii, fig. 25.
[3] Ibid., p. 126, pl. viii, fig. 26; pl. ix, figs. 1–7.
[4] Clarke: Tenth Report New York State Geol. (1891), p. 67, pl. i, fig. 1.
[5] Van Ingen: School of Mines Quarterly, vol. xxiii (Nov. 1901), No. 1, pp. 36–39.

species. In shape it is broadly parabolic; the axis is conical, convex, about one-third the width of the pygidium in front, is not enclosed by a furrow behind, but sinks down rather suddenly to the general level of the lateral lobes in the postaxial piece; there are three distinct narrow rings on the front part of the axis, followed by lateral traces of a fourth; the posterior end of the axis is elevated into a blunt tubercle. The axial furrows converge posteriorly to a little behind the axis and then curve gently outwards. The lateral lobes are flat, horizontally extended, and consist of three pairs of pleuræ, each well-defined and traversed by a diagonal furrow of equal strength, but only the first two pairs of pleuræ end in free points beyond the margin, the third pair not interrupting the regular rounded outline of the posterior edge of the pygidium. The free ends of the second pair, which are alone preserved in our specimen, project as short, broad, slightly recurved points. The postaxial piece, which is broad, appears not to be marked off posteriorly from the third pair of pleuræ, the limiting furrows dying out before reaching the margin. The surface of the pygidium is uniformly tuberculated. There is a wide concentrically striated fascia on the inferior surface, extending inwards nearly to the tip of the axis.

Dimensions.

	mm.
Length	14
Width ... ... (about)	18

Affinities.—The figure given by Schmidt[1] of a pygidium which he attributes to *L. depressus*, Angelin,[2] resembles this specimen in general characters, and particularly in its rounded posterior outline and in the short free points of the two first pairs of pleuræ, the third pair ending within the margin. But the axis is not of the same shape, and has only two rings on it. Schmidt also states that he is doubtful about the characters of the posterior portion, and it may not have a rounded outline behind the second pleuræ. Angelin's figure certainly does not convey the same impression. But *L. affinis*, Ang.,[3] and *L. conformis*, Ang.,[4] in spite of being more pointed behind, are undoubtedly the nearest allies, the shape of the axis, number of segments, posterior tubercle, lateral lobes, pleuræ and furrows agreeing much more closely than any others; and without any hesitation I assign this Slade form to this group which has been called *Metopolichas*.[5] A form from the Keisley Limestone has been referred by the present author[6] to *L. affinis* on the strength of some pygidia and a head-shield, and another to a variety of *L. conformis*.

[1] Schmidt: Rev. Ostbalt. Silur. Trilob., pt. ii (1885), p. 95, pl. iv, fig. 4.
[2] Angelin: Pal. Scand. (1854), p. 70, pl. xxxvi, fig. 4*a*.
[3] Ibid., pl. xxxviii, fig. 4*b*.
[4] Ibid., pl. xxxviii, fig. 5.
[5] Reed: Q.J.G.S., vol. lviii (1902), p. 73.
[6] Reed: Q.J.G.S., vol. lii (1896), p. 427.

LICHAS (METOPOLICHAS) LACINIATUS, Dalman (?).

There is one specimen of a pygidium probably referable to this species from the Slade Beds exposed at the roadside a few hundred yards west of St. Martin's Cemetery, Haverfordwest, in Mr. Turnbull's collection. Though this specimen is not well preserved, the more elongated form distinguishes it from *L. affinis*. *L. laciniatus* has been described from the Bala of the Lake District [1] and other British localities.

LICHAS (PLATYLICHAS) MARGARITIFER, Nieszkowski, var.

Some fragments of head-shields of a species of *Lichas* were collected by Messrs. Marr & Roberts from the Slade Beds of Robeston Wathen and Ben Lomond Cottage, Haverfordwest, but no specific identification was given. Portions with similar characters from the same horizon occur in Mr. Turnbull's collection. They must undoubtedly be referred to that section of the genus which has been designated *Platylichas*,[2] and they are almost indistinguishable from *L. margaritifer*, Nieszk.,[3] of the Baltic provinces, to which a form from the Chair of Kildare Limestone has also been referred. The median lobe of the glabella and the bicomposite lateral lobes have the typical shape and definition of this species; the axial furrows are likewise quite obsolete posteriorly, the fixed cheeks and the fourth lateral lobes being completely fused and forming a gently convex surface, marked off from the median lobe by the additional furrow which connects the base of the bicomposite lobes with the occipital furrow; there is the usual pair of small rhomboidal occipital lobes; and the eye-lobe and furrow are well seen. The surface seems to be finely tuberculated rather than granulated; and there is a median tubercle on the neck-ring in one of the specimens, which is apparently absent in the Russian examples.

Family CHEIRURIDÆ.

CHEIRURUS (s.g. PSEUDOSPHÆREXOCHUS) aff. SUBQUADRATUS, Reed.

The subgenus *Pseudosphærexochus* has been recorded by the author [4] from the Keisley Limestone, and its relations have been discussed in another place.[5] Its presence in the Haverfordwest area has now to be recorded, specimens of head-shields showing the typical features, but not well enough preserved for precise specific identification, occurring in the Slade Beds of Upper Slade in Mr. Turnbull's collection. The form appears to resemble *Ps. subquadratus* of the Keisley Limestone very closely.

[1] McCoy: Synops. Brit. Pal. Foss. Woodw. Mus., p. 150, pl. 1 F, fig. 17 (*L. subpropinqua*).
[2] Reed: Q.J.G.S., vol. lviii (1902), p. 72.
[3] Nieszkowski, Mon. Trilob. Ostseeprov.: Archiv. Liv.-Est-Kurland, ser. 1 (1857), p. 568, t. i, fig. 15.
[4] Reed: Q.J.G.S., vol. lii (1896), p. 421, pl. xx, figs. 10, 11.
[5] Reed: GEOL. MAG., Dec. IV, Vol. III (1896), pp. 117, 161.

EXPLANATION OF PLATE IV.

FIG. 1. *Harpes* sp. 'Horse-shoe' limb. Sholeshook Limestone. × 3.
,, 2. *Ampyx* cf. *rostratus*, Sars. Head-shield. Slade Beds, Upper Slade. × 2½.
,, 3. *Remopleurides Salteri*, Reed, var. *girvanensis*. Slade Beds, Upper Slade. × 2½.
,, 4. *Acidaspis Turnbulli*, sp. nov. Nearly entire specimen, with the exception of half the thorax and pygidium. Sholeshook Limestone, Haverfordwest. × 2.
,, 5. ——— Outline figure of restored head-shield.
,, 6. ——— Restored outline of one of the thoracic segments.
,, 7. ——— Restored outline figure of pygidium.
,, 8. *Acidaspis sladensis*, sp. nov. Head-shield, showing the glabella; the cheeks imperfect. Slade Beds. × 5.
,, 9. ——— Head-shield of a larger individual. × 5.
,, 10. ——— Restored outline of head-shield.
,, 11. ——— Pygidium. × 5.
,, 12. ——— Outline of pygidium restored.
,, 13. *Lichas affinis*, Angelin, var. Pygidium. Slade Beds, Haverfordwest. × 2.

II.—Some Notes on the Gold Occurrences on Lightning Creek, B.C.

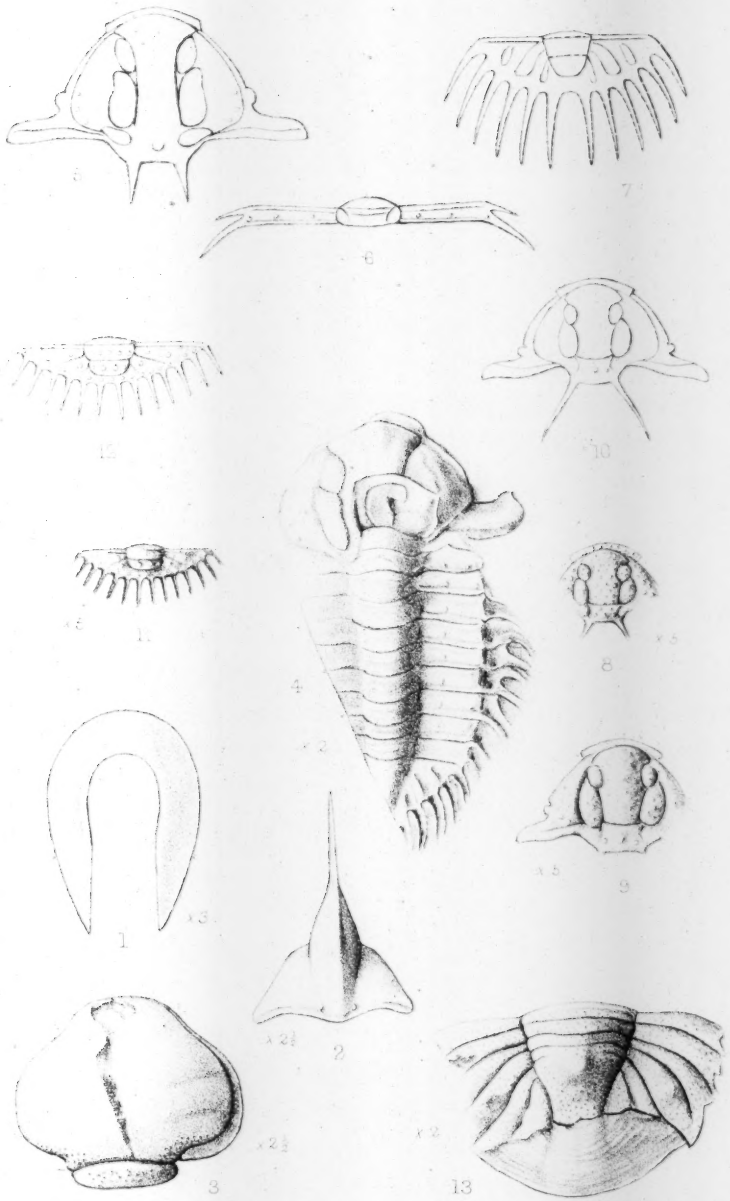
By Austin J. R. Atkin, Esq.

LIGHTNING CREEK occupies a wide valley in a weakened zone in the series of rocks known as the Cariboo schists. It has been stated by Mr. Bowman (Canadian Geological Survey, 1885 and 1886), and confirmed by later observations, that the centre of the deepest known erosion follows very closely the anticlinal axis in these schists. The occurrence of the very rich spots for which this stream is justly famous, both below its present level and at points many feet above it, have long been a source of discussion amongst the miners who worked here. It is hoped these notes gathered during three years studying this difficult problem may be of assistance to future observers, and perhaps lead to the discovery of rich benches in hitherto unsuspected places.

There have been four distinct channels followed by this stream, all of Tertiary age. The oldest or Devil's Lake stream (see map) emptied into a different river from the present creek, and is about 600 feet[1] above the channel of the latest Pliocene stream, at present buried under from 50 to 150 feet of drift of Glacial and Pleistocene age. Between this and the latest Pliocene channel are the Butcher and Dunbar Flat Benches, both the sole known remains of a stream which once ran at this level.

Below these, and only about 20 feet above the deepest channel yet discovered, is the bench belonging to the Point Mining Company, which I have called Fry's Bench. This bench, being more silicified than the rest of the slates, resisted erosion while the stream cut down on the outside. The gravel and gold occurrence was studied here, the other channels being worked out in the early seventies. This small patch—the best of it being only 80 feet long by 10 feet wide—was very remarkable for its richness, an area of 35 square feet having produced as much as 260 ounces of gold. In some

[1] All levels taken by aneroid, both for paper and map.



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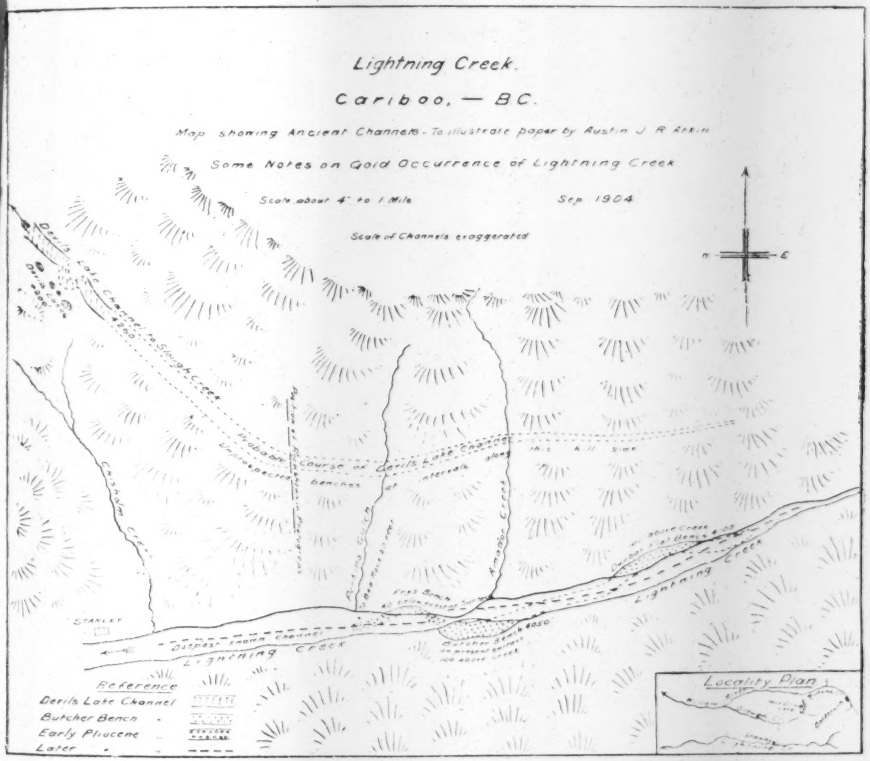
West, Newman imp.

Trilobites from Haverfordwest.

places the gold was so plentiful that the writer has picked up 15 ounces in a few minutes from the crevices in the broken bed-rock. The reason for this striking richness was shown in the patch occupying a pool at the foot of a fall in the old stream.

All the gold was very water-worn and large, the smallest piece being about 10 grains in weight, and was in the crevices of the rock, together with hydrated oxide of iron, which was doubtless the pyrites of that age.

The benches known as Butcher Bench and Dunbar Flat were the same stream of a still earlier date, and produced several of the

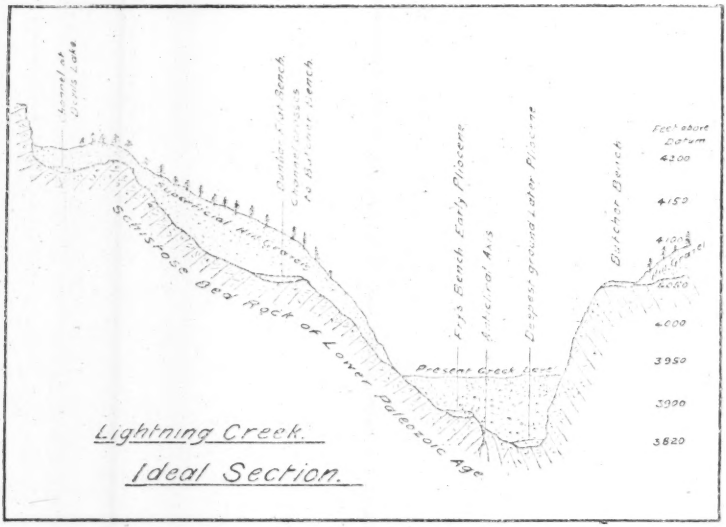


largest pieces of gold found in the country. Some of the nuggets weighed over 30 ounces, but contained a little quartz and were rougher in appearance than those found in the deeper channels. It was the erosion of this channel that enriched the Point Bench and the deeper ground to the left. Most of the quartz probably got washed out of and separated from the rest of the gold on its travel down to the deeper levels.

The most interesting of all the channels of this valley is the oldest or Devil's Lake channel. Emptying as it did into the valley of Slough Creek, it represents a period when the drainage was very

much higher than at present, and may possibly be as old as Miocene. It is the only channel so far discovered in the country of this period, and I have no hesitation in attributing the gold deposits of Lightning Creek to the erosion of this old channel, which also produced the rich benches along Slough Creek (see locality plan) when the watershed drained into Willow River instead of into Cottonwood River as it does at present. The enormous extent of the erosion can be judged when the deepest gutter below the present creek at Stanley is 600 feet lower than the benches above Devil's Lake, which are the only discovered remains of this old channel within the present drainage area of Lightning Creek.

While very little gold remains in Amador Creek, the sudden failure of the auriferous lead on Perkins Gulch appears to indicate the probable level at which this channel ran; there is nothing more



Lightning Creek.
Ideal Section.

suggestive than the rock prominence shown in the photograph.[1] This cliff probably marks a point around which the oldest channel once ran, confined on the outside by the rock prominence. The terraces further along the hill may be Post-Glacial débris resting on the benches of this stream, or the result of the receding waters of Pleistocene times terracing the loose deposits.

Summing up these notes, I look on the richness of the Pliocene channel of Lightning Creek as due to the concentration of the gold contained in the beds of the stream when it ran at the level of Fry's Bench; and on Butcher Bench and Dunbar Flat level at a still earlier date. This last in turn owes its richness to the earliest channel, the course of which I have tried to indicate.

[1] The Editor regrets that the photograph referred to by the author was too small and not sufficiently clear for reproduction by process.

III.—Some Transvaal Eruptives.

By R. F. Rand, M.D., F.L.S.

THE following petrographical notes refer to examples of igneous rocks collected by the writer during a visit to the Transvaal in the Summer of 1904. Thin sections of the rocks have since been made, and it was thought the following condensed accounts of their appearances might perhaps prove a useful record.

Meg. is prefixed where megascopic characters are noted; *Mic.* where the allusion is to microscopic features. The magnification, unless otherwise stated, is one of 60 diameters.

Nos. 1, 2, 3, 4, 5, and 6 are examples of the granite which emerges two miles or so due north of the Johannesburg P.O. (the point to which distances in the Johannesburg district are referred). The Witwatersrand Series of clastic rocks, the gold-bearers, dip away towards the south, their northern edge forming a bold escarpment overlooking the granite. The specimens, collected from different points, have a general likeness and are grey in colour.

No. 1.—Locality: small quarry close to the Hyde Park Estate, 5½ miles north of Johannesburg.

Meg. A medium-grained type. Sp. gr. 2·62.

Mic. Shows the usual granitic type of structure. Quartz bulks largely; it is traversed by strings and bands of minute bubbles, and includes many fine straight needles, some of which are nearly a millimetre in length. They are probably rutile. The felspars are microcline, plagioclase, and orthoclase in about equal proportions. All show alteration, but the microcline is in, by far, the freshest condition. The change is principally one of kaolinization, but amid the cloudiness many fine flakes of muscovite are recognisable. The soda-lime felspar is oligoclase, it shows fine albite twinning, and has a mean refractive index slightly lower than that of the adjoining quartz. The orthoclase is in Carlsbad twins and shows zonary decomposition.

The ferro-magnesian elements are biotite and hornblende in about equal quantities. The biotite is intensely pleochroic, and encloses sphene, sometimes in crystals, but more often in grains. The hornblende is bottle-green in colour, and usually lies in association with the biotite. It frequently encloses epidote, both as crystals and grains. Apatite occurs sparingly, sometimes enclosed in the biotite. A few small zircons are to be seen. Here and there are small patches of a micrographic intergrowth of quartz and felspar, the felspar dominant and quite turbid.

No. 2.—A fine-grained example from the same quarry as No. 1. Sp. gr. 2·59.

Mic. The minerals are the same as in No. 1, but the grains are smaller. The difference between the refractive indices of the quartz and the felspars gives the surface of the section a curiously uneven semblance, the quartz appearing to lie at the bottom of shallow hollows. The biotite shows inclusions of sagenitic rutile.

No. 3. — Locality: Waverley Estate, 5½ miles N.N.E. of Johannesburg.

Meg. A medium-grained type. Sp. gr. 2·66.

Mic. The quartz is of the usual kind, but there is an absence of the rutile needles noted in No. 1. The felspars are microcline, orthoclase, and plagioclase, as before. Hornblende is present, but no biotite. It is pale green in colour, and carries, as inclusions, granules of sphene, small crystals of magnetite, and a little apatite.

Accessories.—(*a*) Sphene, in good crystals of a yellowish-brown colour and carrying numerous magnetite crystals as inclusions. The sphene crystals are sometimes a millimetre in length, so that with a little scrutiny they may be made out in the hand-specimen. (*b*) Pyrites, in crystal-groups and sometimes in grains, sporadic in its distribution. (*c*) Apatite, in fairly large crystals.

Muscovite, calcite, and epidote all occur sparingly, as decomposition-products. Micrographic intergrowth of quartz and felspar is present, but in less degree than in No. 1.

No. 4.—Locality: Norwood, 4 miles north-east of Johannesburg and about $\frac{3}{4}$ mile from the escarpment of the Witwatersrand Series.

Meg. Of rather coarser grain than that of the preceding numbers. Sp. gr. 2·66.

Mic. Shows quartz as in No. 1. The felspars are the same, the orthoclase showing very good zoning. Hornblende and biotite occur, the former preponderating. Mixed up with the hornblende, at whose expense it appears to have grown, is a large quantity of epidote, sometimes showing good crystal outlines. Sphene occurs in good crystals, which occasionally show excellent cleavage-cracks. It is sometimes enclosed among the hornblende-clusters. Apatite as in previous examples.

No. 5.—Locality: a small quarry near stream which escapes towards the granite below Sans Souci. About $2\frac{1}{2}$ miles N.N.W. of Johannesburg and close to the Witwatersrand Series escarpment.

Meg. The rock is of medium grain, its minerals tending towards directional arrangement. Sp. gr. 2·76.

Mic. The quartz is in smaller grains. It appears to have suffered some comminution. The felspar is striped, much decomposed, and largely predominates over the quartz. The hornblende is in large individuals, of greenish colour and irregular outline; the coloration is patchy, and the interior of the crystal often shows bleaching. Pleochroism is strong, yellow to indigo-blue. Sphene, epidote, and apatite are commonly enclosed within the hornblende-groups, the epidote abundantly. A few zircons are noticeable.

No. 6.—Aplitic vein from the same quarry as No. 5.

Meg. Milk-white in colour and holocrystalline. Sp. gr. 2·62.

Mic. Consists almost exclusively of quartz and felspar. Quite rarely a little epidote is to be seen, decomposed at core into calcite; a shred or two of hornblende; and small stray crystals of pyrites. Between crossed nicols one sees a pell-mell of quartz and felspathic fragments, the quartz often in large irregular grains, and, grouped around them, are smaller fragments of plagioclase, mostly with their long axes in rude parallelism. In certain cases the felspar has undergone extreme destruction and is reduced to a granular

mosaic. Of the larger plagioclase fragments, some are bent, some are broken. The microcline appears to be of tougher nature than the plagioclase, having survived in larger fragments; these show a vague, undulatory extinction.

Nos. 7, 8, and 9 present some resemblances among themselves sufficient to warrant their being grouped together.

No. 7.—Locality: near by the spur of the Witwatersrand Series, around which the stream winds in its escape northwards out of the Bezuidenhout Valley. From bed of stream. The rock occupies an intermediate position between the granite and the eruptive which occupies the floor of the Bezuidenhout Valley, a rock which is referred to later on.

Meg. A close-grained, holocrystalline rock, of dark bluish-grey colour. Sp. gr. 2·96.

Mic. The prevailing elements are rhombic pyroxene and amphibole, the two often intergrown. The hornblende is very pale, and appears to be largely derived from the bronzite, of whose crystals it often constitutes the core. The bronzite is in large columns with brush-like endings. Much of it has undergone the usual bastitic alteration. Isolated crystals of hornblende occur, showing good prismatic cleavages. Amidst the foregoing lies greatly decomposed plagioclase with broad albite lamellæ, and having epidote as its chief decomposition-product. There is also a little quartz and a micrographic intergrowth of quartz with felspar. Chlorite is present in a few stray patches. Pyrites occurs in fair quantity. Opaque patches of reddish tinge may be stained leucoxene, which is apparently passing over into sphene. It may denote a pre-existent ilmenite, and sometimes lies in association with the pyrites.

No. 8.—Locality: irregular mass intrusive in the Witwatersrand Series near Sans Souci. A few hundred yards distant from the granite.

Meg. A fine-grained rock, holocrystalline. Colour dark-bluish black and light grey, in fine mottling. The weathered surface is rusty. Sp. gr. 2·91.

Mic. The most abundant constituent is hornblende, pale in colour, sometimes twinned, oftentimes fibrous. It interlaces with a greatly decomposed columnar plagioclase. In the meshes lies a micrographic intergrowth of quartz and turbid felspar. A clear plagioclase, referable to labradorite, is present in quite subordinate quantity. Ilmenite is present, mostly decomposed into leucoxene, and here and there are a few specks of pyrites.

No. 9.—Locality: from a dyke traversing the granite in Bramley township, 6 miles N.N.E. of Johannesburg. The dyke trends north and south.

Meg. Much resembles No. 8 in appearance, but is slightly darker in colour. Sp. gr. 2·99.

Mic. The appearance is ophitic. The meshes of the striped felspar are occupied by serpentine, apparently derived from hornblende, of which some unaltered fragments remain. The hornblende itself is probably largely secondary. The serpentine is frequently

bordered with a hem of chlorite, with pleochroism green to blue. Quartz is present in fair quantity. Plates of ilmenite are abundant, decomposed for the most part into leucoxene. A few crystals of apatite occur.

Klipriversberg Amygdaloid.

Nos. 10 and 11 illustrate this rock, which overlies the Witwatersrand Series some 5 miles south of Johannesburg, where it forms a range of rugged hills. In places it shows a characteristically amygdaloidal structure, which is brought out very clearly by weathering, the resistant quartz amygdules standing out in bold relief.

No. 10.—Locality: northern fringe of Klipriversberg Range by Meyer's Farm, 5 miles south of Johannesburg.

Meg. A dark bluish-grey rock of dull, fine-grained texture, the ground carrying a few glassy, tabular crystals of felspars showing albite striation. Darker spots represent the amygdules, which, in the specimen under review, are small. Sp. gr. 2·83.

Mic. The ground-mass is made up of a mass of felspathic microlites, mostly showing the parallelism indicative of flow. Amidst the microlites is a good deal of granular opaque matter, which is white by reflected light. The microlites are long and slender, and, as they extinguish almost parallel with their length, are probably oligoclase. Some of larger growth are striped. Lying among the felspathic microlites of the ground-mass are numerous fine needles of amphibole, which appear to grow at the expense of the opaque matter noted above, increasing in number as the opacity clears up.

The large felspar phenocrysts are few in number, are much decomposed, and show albite twinning. The ferro-magnesian element of the first generation is represented by pseudomorphs of pale-greenish chloritic matter, granular in appearance, faintly pleochroic, and ranging between crossed nicols from an intensely deep blue to complete isotropism. These pseudomorphs perhaps succeed olivine. They frequently enclose epidote in good crystals.

The amygdular cavities show varying contents. They are commonly filled in part by a material very similar to that of the pseudomorphs, but which in the amygdular cavities passes over into, what is doubtless to be regarded as, isotropic serpentine. This material borders the wall of the cavity, encroaching deeply upon its area; centrally, the core of the amygdule is formed by a mosaic of quartz. Epidote is frequently seen in the chloritic matter, and its advancing growth is indicated by a faint shadow margining its edges; this is pleochroic, and recalls the pleochroic halos common in the biotites, but lacks their intensity. Rutile is an occasional inclusion in the amygdular chlorite. One cavity is almost completely filled with augite, decayed centrally, where it is studded with grains of quartz and magnetite crystals.

No. 11.—Locality: southern edge of Klipriversberg Range, about 8 miles south of Johannesburg.

Meg. Resembles No. 10, but the amygdular cavities are larger and are filled with white quartz. Sp. gr. 2·93.

Mic. Ground-mass microlitic as in No. 10. There is less of the opaque matter and more amphibole in needles and wisp-like flakes. Specks of magnetite are fairly plentiful. Many of the amygdular cavities are entirely filled with a mosaic of quartz, which, in turn, sometimes includes a little pyrites and sometimes epidote. Other cavities are filled as in No. 10, and again others carry epidote exclusively.

Eruptive occupying the floor of the Bezuidenhout Valley.

Nos. 12, 13, 14, 15, 16, and 17 as examples.

This rock has a strong likeness to the Klipriversberg amygdaloid; it is separated from it, however, by a large section of the Witwatersrand beds, some 4 or 5 miles of their outcrop intervening between them. The rock is schistose, in places, at the upper, narrower end of the valley. Lower down and beyond the spur of the Witwatersrand Series, which there terminates the northern flank of the valley, the rock comes into relation with that described under No. 7, an intervener between it and the granite.

No. 12.—Locality: Bezuidenhout Valley township, north side of stream, 2½ miles east and a few points north of Johannesburg.

Meg. Closely resembles No. 10. The felspar crystals, however, are small. Sp. gr. 2·87.

Mic. Felspathic microlites are larger than in No. 10, some of them forming small striped laths. Among them is much amphibolic material, in needles and wisps, and a good deal of the opaque white material noted in No. 10. Epidote occurs plentifully throughout the section in irregular grains.

No. 13.—Locality: same as No. 12.

Meg. A weathered specimen, amygdular. The contents of the amygdular cavities have, in many instances, weathered out, so that there is a partial reversion to the original cellular condition, a change reflected in the low specific gravity, viz. 2·47.

Mic. A microlitic ground-mass with occasional members of somewhat larger size. Interstitially there is much chlorite, pleochroic, and nearly isotropic. Scattered abundantly throughout the section are irregular patches of a dark-brown, semi-opaque material, white by reflected light. I believe it to be leucoxene in course of alteration into sphene, and perhaps rutile. Many of the amygdular cavities are empty; where filled, the peripheral portion consists of completely isotropic serpentinous matter, sometimes iron-stained; the central portion is made up of quartz-mosaic.

No. 14.—Locality: from a point lower down the Bezuidenhout Valley, opposite the Geldenhuis tailings-heap.

Meg. A close-grained, bluish-black ground, enclosing opaque-white tabular crystals of felspar. One of these in the specimen measures 2 cm. in length. Sp. gr. 2·87.

Mic. The ground-mass consists of small plagioclase laths of more acid type than the felspathic phenocrysts. These latter are greatly decomposed. They are probably to be referred to oligoclase-andesine. Among the laths lie dirty-green, platy forms with

brush-like endings. These are probably hornblendic. There is much epidote, in large irregular grains, sometimes interstitial, sometimes enclosed in patches of chlorite. The amygdular cavities are filled as in previous examples. Some of their chloritic matter encloses biotite, which is apparently growing at its expense. This specimen shows an approach towards the ophitic structure of the diabases.

Nos. 16 and 17.—Locality: Bezuidenhout Valley township, 3 miles east of Johannesburg. Both of these examples are schistose, probably as a result of dynamic metamorphism. The vicinity manifests, as has been pointed out by Drs. Hatch, Corstorphine, and others, a high degree of faulting.

No. 16. Sp. gr. 2·71.

Mic. Individual detail is gone, and the body of the rock is now made up of an exceedingly fine-grained crystalline basis, probably the ground-down fragments of the felspathic microlites and crystals. This ground-mass is traversed by strings of yellowish-green chloritic matter and streaks of iron-staining. These course in rude parallelism, approaching and diverging to leave lenticular interspaces. Large irregular plates, of what is probably titaniferous iron decomposed into a red-stained leucoxene, occur freely, and around these patches the strings frequently wind.

No. 17.—*Meg.* The schistose character is evident in the hand-specimen. Sp. gr. 2·58.

Mic. The general features resemble No. 16. The amygdular cavities are much flattened out. The grains of their quartz-mosaic have sometimes assumed a degree of parallelism, the direction of arrangement being obliquely across the cavity and not in line with its long axis.

Note.—From the foregoing it will be seen that the Klipriversberg amygdaloid and the Bezuidenhout Valley eruptive are much akin.

No. 18.—Locality: an intrusive in the Witwatersrand Series; exposed in Witpoortje Kloof, some 12 miles west of Johannesburg.

Meg. A dark bluish-black rock, holocrystalline, faintly mottled, and of medium grain. Specks of pyrites are conspicuous. Sp. gr. 2·92.

Mic. The rock has the structure of the diabases, large felspathic laths constituting a framework amid which the ferro-magnesian elements are disposed. The felspar is greatly decomposed, but the albite striping is to be made out. The ferro-magnesian constituents are augite and olivine, intermixed in crystalline clusters. Both are faint yellowish-brown in colour. Augite predominates. Both the augite and the olivine are in course of alteration into serpentine, and in both the alteration comes as an opaque cloudiness advancing from the surface inwards. Detached pieces of serpentine and of chloritic matter lie about in the section, the latter enclosing grains of epidote. Large crystalline plates of magnetite are frequent. More rarely, beautiful patches of pyrites occur, arranged in the filigree-like forms it so often assumes.

No. 19.—Locality: surface-exposure 2 miles east of Boksburg. Possibly of Karoo age.

Meg. Holocrystalline, bluish-black rock, of fine grain. Sp. gr. 2·95.

Mic. The ground-mass is made up of numerous short laths of plagioclase (with albite twinning) and small irregular grains of augite and olivine; the olivine grains being the larger. These are largely decomposed into a dark, greenish serpentine. Amidst the ground-mass lie larger elements—(*a*) groups of large plagioclase crystals (labradorite); (*b*) occasional large irregular grains of olivine; (*c*) crystalline patches of magnetite; (*d*) irregular green patches of serpentine succeeding olivine; (*e*) a few long, lath-like crystals of twinned augite, sometimes showing erosion. The rock is referable to the olivine-basalts.

Beyond Pretoria.

No. 20.—Locality: from summit of range of hills about 10 miles north of Pretoria, *viâ* Wonderboom Poort, the Poort being a defile in the Magaliesberg Range where river, road, and rail jostle each other in their passage through. The range from which the rock was collected runs nearly parallel with the Magaliesberg. "Pyramids" vicinity.

Meg. A holocrystalline rock of medium grain, dark grey and granitoid. Sp. gr. 2·92.

Mic. A rock of simple constitution, its elements consisting of augite, frequently diallagic; and labradorite; with the allotriomorphic arrangement of the granular rocks. The proportion is about one-third augite to two-thirds labradorite. A gabbro of simple type. The augite is much decomposed and is often turbid. It contains grains of magnetite as decomposition-product. Little patches of chlorite are sometimes included, and, in places, one sees a marginal alteration of the augite sending invading strings of chlorite into the surrounding felspar. The labradorite is comparatively fresh, showing broad albite lamellæ, and, quite rarely, pericline striation.

No. 21.—Locality: outcrop upon the flats midway between Wonderboom Poort and the range from which No. 20 was collected. It probably constitutes part of the same rock-mass.

Meg. A very coarse-grained, holocrystalline rock consisting of large black shimmering crystals set in a white matrix, showing frequent cleavage-faces. Sp. gr. 2·9.

Mic. Large crystals of augite, twinned, with basal cleavage, giving the herring-bone structure, are conspicuous. The crystals frequently show a marginal alteration into brown hornblende. Grouped with the augite are large crystals of hypersthene, partially converted into bastite. Like the augite it too shows a marginal conversion into brown hornblende. The hypersthene is rather more abundant than the augite. The felspar (labradorite) is more decomposed than that of No. 20. It shows much granular opacity. Combinations of Carlsbad, albite, and pericline twinning occur. The crystals are frequently crowded with long needle-like inclusions, whose regular disposition in planes shows an approach to schiller-structure. These inclusions sometimes occupy patchy areas in the interior of

a crystal; their extension is attended by a change in the orientation of the axes of elasticity of the felspar. As accessories, a few small zircons are to be seen.

No. 22. An irregular intrusion in the Magaliesberg Series, north of the Van der Merwe Railway Station, Pretoria–Delagoa Bay line.

Meg. A holocrystalline rock of grey colour and fine grain. Sp. gr. 2·69.

Mic. Shows interlacing bars of a greatly decomposed plagioclase interwoven with a rhombic pyroxene, which is mostly altered into bastite. The meshes of this framework are occupied by a micrographic intergrowth of quartz and semi-opaque felspar, the quartz preponderating. Some magnetite occurs, and hornblende, sparingly. A small vein traversing the section is filled with calcite.

No. 23.—Locality: dyke in the Magaliesberg Series, north of Van der Merwe Railway Station.

Meg. Has a general likeness to No. 22, but is of somewhat coarser grain. Sp. gr. 2·83.

Mic. There is a framework of decomposed plagioclase, with rhombic pyroxene as in No. 22, also much quartz in micrographic intergrowth with felspar. In addition there is pale augite partly altered into uralitic hornblende, and plentiful large flakes of ilmenite partly decomposed into leucoxene. Patches of serpentine occur as results of complete decomposition of rhombic pyroxene.

Note.—In no Transvaal instance has the writer observed the violent tingeing of augites so frequently seen where augite is associated with titanium-bearing ores.

No. 24.—Locality: dyke in the Magaliesberg Series, north of Van der Merwe Railway Station.

Meg. A bluish-black rock, of medium grain, partly crystalline. Scratches under the knife. Sp. gr. 3.

Mic. The rock consists of olivine, enstatite, and augite. The olivine is for the most part serpentinized; the decomposition is of the usual type along the cleavage-cracks. The serpentine is greenish, sometimes showing a reddish iron-staining. Where the augite shows change it is in the shape of an advancing cloudiness. The enstatite is fairly fresh, but shows a little of the usual bastitic alteration. Octahedra of magnetite occur. There are also a few flakes of biotite; and, quite rarely, narrow laths of plagioclase.

The rock is interesting as an example of the ultra-basic type.

Vicinity of Klerksdorp.

Locality: ten miles north of Klerksdorp. Intrusive mass occupying the floor of a broad valley between two sedimentary series, usually regarded as being of Witwatersrand age.

No. 25.—*Meg.* A holocrystalline rock of fine grain. Dark-grey in colour. Sp. gr. 2·96.

Mic. Shows numerous plagioclase crystals of small and medium size, among which are disposed fairly large crystals of augite, light yellowish-brown in colour, twinned and herring-boned; also, larger irregularly-shaped crystals of enstatite; neither augite nor enstatite

having definite outline. The greater stability of the augite, as compared with the enstatite, is very noticeable, this last showing advanced bastitic change. The felspar crystals are in good condition. They consist of labradorite. Many show beautiful zoning, the zones varying in constitution, and usually following the rule of increase in acidity on passing from core to crust. Sometimes, however, relatively basic and acid zones are seen to regularly alternate. Ilmenite occurs, sparingly, in regular plates, and there are a few scattered irregular grains of magnetite. It is interesting to compare this rock with Nos. 20 and 21 from beyond Pretoria.

No. 26.—Locality: steep, rocky hill behind the old town of Klerksdorp, west of the Schoon spruit.

Meg. A rock with dark-blue, stony ground in which lie opaque, white, quadrangular crystals and glassy-looking blebs. The structure is typically porphyritic. The weathered surface is scoriaceous-looking, owing to the weathering out of the porphyritic crystals; it is inclined to rustiness in colour. Sp. gr. 2·56.

Mic. The ground-mass is micro-felsitic, with some residual glass. Its more transparent portions show vague and ghost-like crystalline outlines, as though the excessively fine granules were on the way to crystalline form. The phenocrysts are: (*a*) Quartz, its crystal outlines rounded off by the magma; the crystals cracked and showing occasional inclusion of the ground-mass. (*b*) Felspar: much decomposed, shows albite twinning, sometimes of exceeding fineness; this is sometimes associated with pericline twinning. It may be regarded, provisionally, as an acid-oligoclase. The edges show irregular corrosion, and there are inlets of the ground-mass within the crystals. (*c*) Orthoclase: in simple Carlsbad twins, clouded like the foregoing, the crystal edges slightly rounded, but not worm-eaten-looking as in the case of the plagioclase. (*d*) Nearly opaque crystals of hornblende; relics of magmatic corrosion. They are recognisable by the shape of their cross-sections and cleavage-fragments. (*e*) Pseudomorphs of green chlorite, following augite. These show a narrow, dark resorption-border. Specks of magnetite and grains of calcite are to be seen in the chlorite. The rock is interesting as a relatively acid type of eruptive, and may be classed as a quartz-porphyry.

No. 27.—Locality: about eight miles N.N.E. of Klerksdorp.

Meg. A bluish-black rock of fine-grained groundwork, which includes many fine, angular, glassy fragments. Sp. gr. 2·68.

Mic. The rock consists of crystalline fragments and lapilli cemented together by a glassy, tufaceous matrix. The crystalline fragments consist chiefly of quartz; they are sometimes rounded, but more often are irregular in shape and sharply angular. The fragments contain the strings of inclusions of the type seen in granitic quartz. Here and there are crystalline aggregates of pyrites, and fragments of microcline and plagioclase. The lapilli vary a good deal in size. A piece of one large one flanks the whole section. It consists of an interlacing framework of plagioclase bars, whose meshes are filled by opaque, unindividualised, glassy matter,

which is being encroached upon by the surrounding crystals. Many of the smaller lapilli show a similar structure. Others consist of a mosaic of quartz grains, probably with felspathic ones intermixed; the mosaics of varying grain, some being coarser than others. A little calcite is present in irregular patches.

We have probably here to do with a fine volcanic breccia.

Note.—My time at Klerksdorp was limited; the neighbourhood is interesting, and appears to be one around which considerable volcanic activity has been focussed.

No. 28.—An obsidian. This does not fall within the Transvaal Series. It was given to me by Mr. Sydney Ryan, who collected it upon the Lebombo Range, which lies in Portuguese territory, between the eastern border of the Transvaal and the East African coast.

Meg. Has the appearance of pitch. Sp. gr. 2·3.

Mic. The rock consists of a light-brown glass; × 250. The glass is seen to be crowded with trichites disposed almost exclusively in stellate forms, the delicate filaments radiating outwards from a central point. These are, in turn, very frequently arranged in axiolitic strings, running in parallelism along the lines of flow. There are a few spherulitic groups. They give the usual cross in parallel, polarised light. Some of the crosses break up into distinct hyperbolas as the stage is rotated. A few rounded crystals of sanidine constitute the only crystalline elements noted.[1]

IV.—An Occurrence of Scheelite, near Barkerville, B.C.

By Austin J. R. Atkin, Esq.

LYING in the heart of the gold belt known as the Barkerville District, Hardscrabble Creek was discovered by the pioneer prospectors in 1867, and has ever since been noted for the number of heavy minerals associated with the gold. Galena and various iron minerals were recognized, but the most troublesome was a heavy white substance, which caused great trouble to the miners by packing in the sluice-boxes so tightly that the gold was carried over the firmly set particles by the amount of water required to keep the riffles clean. An investigation by an economic geologist of high standing of some lumps of the alleged mineral showed it to be barium sulphate, and no examination was made of the smaller particles.

Last Winter the author was asked to suggest some possible way of getting rid of this most troublesome mineral, and went down to see the workings. While there some mineral was noticed that was certainly not barytes, and a careful examination—since checked many times—showed the presence of scheelite of good quality. Shortly after the author's examination the white mineral disappeared, so he advised a careful search for the reef, or deposit, close to the face being worked at that time. Very little search revealed this

[1] The thin sections were cut for me by Mr. Gregory, Mineralogist, of Kelso Place, South Kensington.

interesting deposit, the second instance of the ore being discovered in British Columbia, and the only deposit in the province that shows any chance of proving of economic importance. The ore occurs in a zone of country rock, altered by the infiltration of silica and calcite, bounded on the north by an altered mica-schist. The width of the altered zone has not yet (August, 1904) been determined, but it has been proved scheelitiferous for a width of about 12 feet.

The ore so far developed seems to occur under two distinct conditions, as an associate mineral with iron pyrites and galena in small quartz veins; and in 'vugs' in the country rock, sometimes quite pure and at others mixed with a little quartz. The undetermined dark mineral—columbite (?)—occurs in such small quantities as to be of no value. No decomposition products of scheelite have so far been discovered, although the enclosing schist is much discoloured and altered by infiltering solutions.

The discovery of this rare earth in a place well known for so many years should be remembered when in districts which have been much less thoroughly explored, in which an examination of the heavy materials recovered in the process of Placer Mining may show rare minerals of the greatest economic importance.

NOTICES OF MEMOIRS, ETC.

NOTES ON THE GEOLOGY OF CYPRUS TO ACCOMPANY A GEOLOGICAL MAP OF CYPRUS. Compiled by C. V. BELLAMY, F.G.S., M.I.C.E., F.R.M.S., late Director of Public Works in Cyprus. Small 8vo; pp. 16. (London: Edward Stanford, 12, 13, and 14, Long Acre, W.C., 1905. Price 6*s*.)

THE Geological Map of Cyprus[1] and the descriptive text accompanying it are the result of observations extending over a period of five years during which Mr. Bellamy was stationed in the island. He acknowledges the assistance he has received from Mr. A. J. Jukes-Browne[2] and Dr. J. J. H. Teall.

The following is an abridged account of Mr. Bellamy's description of the island:—

1. *Physical Features.*—The Island of Cyprus lies in the extreme eastern basin of the Mediterranean Sea, its distance from the shores of Syria on the east and Asia Minor, or, as it is called locally, Anatolia or Caramania, on the north being about 60 miles in each case. It measures about 140 miles from south-west to north-east, and about 60 miles from north to south; it contains some 3,584 square miles.

[1] Printed in colours; size, 30 by 22 inches; scale, 5½ miles to an inch (1 : 348,480). [The actual size of map to the margin of the engraved plate is 24 by 18 inches.]

[2] See also paper by C. V. Bellamy and A. J. Jukes-Browne read before the Geological Society of London, January 4th, 1905 (GEOL. MAG. for February, 1905, pp. 87–88).

The coastline is very irregular and indented with several extensive bays, the chief of which are those of Famagusta, Larnaca, Limassol, Akrotiri, Krysokhou, and Morphou. About midway along the southern seabord is the irregularly rectangular promontory of Akrotiri, on which is situated the Limassol Salt Lake; this promontory culminates to the south-east in the conspicuous headland of Cape Gata. In the north-east the island tapers off into the remarkable peninsula of the Carpas, which is some 50 miles long and nowhere more than 7 or 8 miles wide, terminating in Cape Andreas, off which is situated the group of barren rocky pinnacles comprising the Klides Islands.

South of Famagusta is the rugged headland of Cape Greco, backed by a table-topped rock, a striking feature to navigators, while at the western and north-western end of the island are Cape Epiphanios or Acamas and Cape Kormakiti.

The island is very mountainous. Along the northern seabord stretch the Kyrenia Mountains from Cape Kormakiti until the Carpas commences, and many of their summits exceed 2,000 feet in height, the range culminating in Buffamento, 3,135 feet. In the south-west central portion of the island rise the great masses of the Troödos Adelphi and Olympus Mountains, the summit of the first being Mount Troödos or 'Khionistra,' 6,406 feet above the sea. The general trend of the mountain ranges is in an easterly and westerly direction.

Between these two ranges lie the central plains of the Mesaoria extending from Morphou on the west to Famagusta on the east. These lands, which comprise the washings of centuries from off the adjoining mountain slopes, are of great fertility and are given over to the cultivation principally of cereals, to which, indeed, the whole of the low country is devoted. The mountain slopes are appropriated to the cultivation of the vine, and the summits are clad in pine-trees, ilex, arbutus, juniper, etc. The deep and narrow valleys which seam the mountains enjoy great richness of soil, which yields successive crops of wheat, barley, cotton, maize, millet, potatoes, etc., and supports the olive, mulberry, cherry, hazel, walnut, fig, apricot, apple, and fruit trees of various kinds.

The geology of Cyprus was dealt with exhaustively by M. Albert Gaudry in the "Mémoires de la Société Géologique de France," ser. II, vol. vii (1862), to which a map was attached, but the latter was compiled from a previously existing rough survey of the island of doubtful accuracy. Other writers include MM. Unger and Kotschy, "Die Insel Cypern" (Vienna, 1865), and Mr. R. Russell, C.E., in a "Report on the Existing Water Supply of the Island of Cyprus" (Foreign Office, 1881).

A map of the island on a scale of one inch to a mile, prepared from a trigonometrical survey, executed under the direction of Captain H. H. Kitchener, R.E., was published in 1882. A smaller map, reduced from the Government Survey, has furnished the author with a basis for the geological map noticed in this key.

TABLE OF FORMATIONS.

Age.	Character.	Distribution.	Local Definition.
Cretaceous.	Compact limestone, marble, etc., and associated igneous rocks.	Kyrenia Mountains and Paphos District.	Trypanian, derived from Trypa Vouno, a summit of the Kyrenia Range.
Highest Cretaceous and Lower Eocene.	Not represented in Cyprus.		
Upper Eocene.	Sandstone, shales, grey marls, conglomerates, and breccia.	Flanks of the Kyrenia Mountains, north and south side of Central Plains, Carpas, and Paphos.	Kythræan, from Kythræa, in the neighbourhood of which this series reaches its greatest development.
Oligocene.	Grey marls, yellow and grey-green clays, gypsum, selenite, alabaster, etc. Tabular white calcareous marls, chalk, flint, sub-crystalline limestones.	North coast, Carpas, north and south of Central Plains, north, east, south, and south-west of Troödos Range.	Idalia beds, derived from Dali, ancient Idalia, where these marls reach marked development. Athienou stone, etc.
Break.	Igneous rocks of the	central and southern	areas.
Pliocene and Pleistocene.	Calcareous sandy limestone, hard or friable. Sands, conglomerates, alluvium.	Low country generally, coast littorals, Central Plains, Foot Hills, etc.	Kyrenia rock, Nicosia Beds, Ag. Paraskevi, Famagusta, Cape Pyla, and Ag. Phyla Stone.

2. *Trypanian Limestone of the Kyrenia Mountains, etc.* (*Cretaceous*). The areas occupied by this formation are indicated on the map in pink. The Kyrenia Mountains constitute the northern rampart of the central plains of the island, and commence at a point about 6 miles eastward of Cape Kormakiti on the northern seabord. The spot is known as 'Skasmata,' a term suggestive of the peculiar physical features of the neighbourhood. From this point, for a distance of 28 miles, the range trends in a direction east by south, and in the neighbourhood of Kythræa changes towards east by north for 30 miles to Komi Kebir at the commencement of the Carpas. Though its extreme length is 58 miles the formation is nowhere more than 3 miles wide, and as the summits of the range frequently reach an altitude of between 2,000 and 3,000 feet, some idea may be gathered of the precipitous nature of these mountain slopes.

The whole of this range consists of hard compact limestones, except for occasional intrusions of igneous rock, and with the exception of a small outlier near Akourso in the Paphos District, these limestones are not encountered in any other part of the island. The characteristics are compact limestones and marbles of several

kinds: white, cream colour, or veined with yellow. They are usually very hard, and include a large variety capable of yielding decorative stone of considerable beauty.

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These limestones and shales are the oldest rocks in Cyprus, and form the foundation on which the rest of the island has been built up. Gaudry remarked that they bear much resemblance to the Cretaceous rocks in other parts of the eastern Mediterranean basin. He compared them with the Hippurite Limestones of Attica, since assigned to the Cretaceous age, and estimates their thickness at 6,500 feet. There is a striking and apparently entire absence of fossil remains in this formation, which causes some doubt as to its correct classification.

At intervals along the axis of the Kyrenia Mountains there occur masses of igneous rocks which have intruded into or through the limestones. These are coloured brown on the map. Their presence may be responsible for the production of the more crystalline varieties of limestone by contact-metamorphism, but the general compression and uptilting of the beds has probably been accomplished by earth-movement which produced the long anticlinal axis of the chain, and so steep is the angle of this axis that the beds are frequently in a nearly vertical position.

Specimens recently collected and submitted to Dr. Teall include augite-biotite-syenite, ophitic olivine-dolerite, and decomposed liparite, from the gorge of the Panagra River near Myrtou; rhyolite or white quartz-felsite near Pentadactylos; with jasper from near Buffamento and other localities.

3. *The Kythræan Series* (*Upper Eocene*).—This is a formation of sandstone and shales. It is indicated on the map by a green tint, and its beds flank the northern mountains both along their north and south sides, extending from Cape Andreas on the east to Morphou Bay on the west; they also occur on the southern and western slopes of the southern or central range.

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The greatest development to which these beds attain occurs in the neighbourhood of Kythræa, consequently it has been considered convenient to call them the 'Kythræan Series.' They consist of calcareous sandstone shales, brown, grey, or grey-green in hue, and on the southern slopes of the Kyrenia Range, where they are most marked, present a series of billowy undulations, which, since the British occupation of Cyprus, have been known as the 'Hummocks.'

The conglomerates of this series are seldom found except on the slopes of the Kyrenia Mountains in the neighbourhood of the Trypanian limestones; they contain fragments of rock which undoubtedly belong to the latter, but have been separated therefrom and incorporated in the more recent formation. The best instances of the occurrence of these conglomerates are at St. Catherine's Pass, the Akanthou Gap, and east and west of the village of Akanthou; they have not been observed in any force elsewhere. Their con-

stituents are principally water-worn fragments of Trypanian limestones, marbles, and flints.

The breccias are compounded of unworn fragments of the older Trypanian limestones, and are of frequent occurrence along the flanks of the Kyrenia Mountains. They vary in hue and are either blue, pink, yellow, brown, or white, and at times they combine fragments of all these varieties, producing an agreeable effect.

* * * * * *

No fossil remains have yet been found in any part of the Kythræan Series.

Gaudry's description of these beds, as corresponding with the Macignos of Italy, would appear to place them alongside the tassello or allied to the Vienna sandstones or 'Flysch.' They belong probably to the Upper Eocene series. Having regard to the frequent flexures and undulations of these beds, I doubt if their thickness amounts to more than 2,000 feet, though Gaudry put it at 6,000.

4. *The Idalian Series* (*Oligocene*).—Probably the most characteristic of the geological formations represented in Cyprus are the grey friable and the white calcareous tabular marls, the latter of intense whiteness. Occasionally they pass into pure chalk, and in many localities contain quantities of flint—pink, greenish, or translucent—occurring in bands of from four to six inches in thickness. In the grey marls of the Oligocene are intercalated large masses of gypsum and selenite, but their prevailing characteristic is friable matter, yellow, brown, or grey-green, of the consistency of clay.

These two groups of beds are distributed all over the island, and are indicated on the map by a yellow tint. The white marls reach their greatest development on the southern side of the great igneous masses of the Troödos Range. From the neighbourhood of Kophino and Lefkara right through the southern slopes of these hills, they are in great force.

It may be remarked that the white marls occupy that part of the island where the best wine comes from. The so-called 'Wine Villages'—Ag.[1] Ambrosios, Mallia, Vasa, Omodhos, Kilani, etc.—are all within this area, and in this neighbourhood the aspect of the country resembles the wide rolling downs and chalk hills of Wiltshire, but the illusion is dispelled when one perceives the deep gorges with their precipitous sides in which the torrents flow.

The intense whiteness of these tabular marls has, no doubt, a considerable influence upon the temperature of the atmosphere over the region where they are found. The glare from the white soil is extremely painful to the eyes, necessitating the use of coloured glasses to protect them; and the heat thrown back from the bare white rocks is frequently intolerable, aggravated as it is by the infrequency of foliage and shelter-giving trees.

In the neighbourhood of Dali, where the conspicuous development

[1] Ag. (incorrectly printed "Ay." in Mr. Bellamy's Key to the Map of Cyprus) is a contraction for Ἅγιος, Haghios, = *Saint*, prefixed to many names of towns and villages in Cyprus.—Edit. Geol. Mag.

of white marls and limestones would seem to have suggested to Russell the adoption of the term 'Idalian' to define them, great rounded hills occur in a succession of undulations extending from the neighbourhood of Margi on the west to Athienou on the east, parallel with the Idalia, or Yalias River.

At Athienou these beds pass into a massive granular limestone, of finer quality and less density, which yields a very useful material known as Athienou Stone, easily cut and much used in the manufacture of a number of different utensils for domestic purposes.

Near Psathi, compact and massive beds of fine-grained gypsum of straight cleavage are worked for the extraction of paving slabs known as 'marmoras.' Their cleavage is very true and even, and their texture is such that they can be cut with a saw and smoothed with a plane. These beds also contain a quantity of native sulphur, in veins and nodules.

Ochres are found principally at Mavrovouni near Larnaca, and also near Limassol, where they are worked for terra umbra, a considerable export trade in which is carried on.

Fossil remains are not numerous, except among the white, compact, chalky marls, which contain a few shells and Echinoderms similar to those to be met with in Malta and Sicily. Some of the limestones, however, are largely made up of the minute shells of Foraminifera, and resemble the Globigerina limestones of Malta.

With regard to thickness, it is not easy to give an estimate because of the frequent flexures, but they probably range from 1,500 to 2,000 feet.

5. *The Igneous Rocks of the Central Mountains.*—These rocks form a tract of mountainous ground which extends for a distance of about 60 miles, with an average breadth of 17 or 18 miles. It includes the mountain groups known as the Machera on the east, the Adelphi and Troödos Ranges in the centre, and the Tillyria Mountains on the west; it extends from a point a few miles to the north-west of Larnaca to the shores of Morphou and Krysokhou Bays in a continuous mass. North-east of Larnaca is an inlier in the neighbourhood of Stroullos and Mavrovouni, and another smaller isolated outcrop occurs near Petrophani to the westward of Athienou on the main road, and about half-way between Nicosia and Larnaca.

In the district of Paphos and in the extreme western end of the island are other outcrops, such as that near Fontana Amorosa, near Ag. Epiphanios, Cape Acamas; at Ag. Ismenas, Ag. Yeorghi, Cathika, and Akourso.

The central mountains are the highest ground in the island, and include the great dome-shaped mass of Troödos, the summit of which, 'Chionistra,' is 6,406 feet above the sea, and the Adelphi Range, which culminates in a height of 5,305 feet.

The areas occupied by these rocks are coloured brown on the map.

The ophitic rocks Gaudry calls ophitones and spilites. These terms are now obsolete, but were formerly applied to the rocks which are now known as diabase and dolerite; he also describes a spherulitic rock, which seems to correspond with that now known

as variolite. These are all composed of labradorite-felspar and augite. Aphanites, or fine-grained diabases, also occur.

Basaltic rocks are of frequent occurrence, especially in the Tillyria district; specimens obtained there by me have been identified by Dr. Teall as basalt, and one as augitite, a rock of the limburgite group, but without any olivine.

The serpentine rocks occupy the region of the highest mountains of Troödos, and are bounded by Troöditissa on the south and Evrychou on the north, while they also occur at Phinicarga, Akourso, Cathika, Ag. Nicola, and Ag. Aconas in the Acamas. On the south and east slopes of Troödos they are fibrous and laminar in texture, and contain asbestos.

The eupholites or felspathic serpentines form an intermediate stage between the serpentine and granitone or euphotide, and abound on the side towards Prodromos.

The gabbros are found towards Evrychou and from Prodromos to Akourso. They occur in bands among the masses of diabase and aphanites about Kykkou and again at Ag. Nicolaos in the Acamas.

Diabase is the variety most prevalent among the igneous rocks of Cyprus. They are generally fine-grained, of a grey-green, blackish, or dull-green hue; frequently much weathered, broken up and decomposed, particularly in the neighbourhood of the sedimentary rocks.

Where the Pliocene rocks rest on these igneous rocks they are not altered, and this fact proves that the intrusion of the volcanic rocks took place in the interval between the formation of the Oligocene and Pliocene rocks of Cyprus.

6. *Pliocene and Pleistocene.*—The deposits comprised in the more recent formations, namely, the Pliocene or later Tertiary, and the Pleistocene or Quaternary strata, are indicated on the map by a blue tint.

They extend over the Central Plains, the coast littorals, and are distributed over the foot hills and low country generally, and they rest unconformably on all the older rocks. The Pliocene is represented by calcareous sandstones, conglomerates, sands, and calcareous tufa, while the Pleistocene beds comprise principally gravels, travertine, the alluvial deposits of the Mesaoria, and the raised beach sandstones of the sea-shore. They may be classified under the following heads, namely :—

Kyrenia Rock, Nicosia Beds } Calcareous sandstones and marls.
Raised beaches.
Conglomerates.
Alluvium.

The two first names were adopted by Russell to indicate certain variations of the same formation, soft limestones formed from calcareous sands and consisting almost entirely of minute organic débris, small worn fragments of shells and other marine organisms, loosely compacted together and containing a small percentage of quartz sand. Both are of Pliocene age.

The beds vary slightly in texture, sometimes compact and durable, and at other times soft, friable, and soiling the hands. They are almost invariably disposed in horizontal beds, having a surface coating or crust of tufa-like carbonate of lime. They vary also in colour between light yellow to reddish brown, but its hue is seldom any criterion for its texture. Those beds are found principally at Kyrenia, a little to the west of the town, at the hill of Ag. Paraskevi, Nicosia, at Famagusta, near Cape Pyla, and Cape Gata, where the quality, appearance, and texture are all very similar, namely, semi-compacted, buff-coloured, and easily worked with the tool.

At Yeri a darker, harder, and finer-grained material occurs. Near Kalopsyda and Kouklia sepia-coloured, fine-grained, friable free-stones are found in extensive masses. Near Strongylo and Vatili they are straw-coloured, very friable, and fine-grained, having little or no durability. Near Kyra is a coarse-grained rock, reddish or brownish in hue, and of a durability equalling, if not surpassing, that of the Ag. Paraskevi rock.

At Ag. Phyla, near Limassol, are extensive quarries of a fine-grained, light-yellow, compact stone, possessing many good qualities. At Paphos the texture is coarse, less compact, and more friable than is found among the coarse-grained qualities. It is dark brown in colour. At Skoulli, in the valley of the Krysokhou River, a compact, fine-grained, light-yellow rock is found with horizontal veins or bands of dark-grey or greenish-grey matter.

From Yerolakko, on the west of Nicosia, following the banks of the Pedias River as far as Deftera, are large masses of the fine friable yellow variety, changing towards Aradiou into a clayey sand, alternately dark brown or grey green, suggestive of the presence of glauconite. The argillaceous beds near Deftera contain numerous Oyster shells—*O. edulis.*

Towards Laxia, south of Nicosia, are extensive deposits of oyster shells, from the abundance of which is derived the name 'Ostrakoudhies,' given to a prominent hill on the west side of the main road from Nicosia to Limassol. Great masses of friable rock are found towards Ag. Sogomenos, where the texture is very variable and has produced striking results during the process of weathering.

7. *Brief Summary of the Physical History of the Island.* — The oldest strata represented in Cyprus are the Trypanian limestones, the characteristic element of the Kyrenia Mountains. They have been assigned to the Cretaceous age, and form the foundation or platform on which the newer rocks have been laid down. Apparently they formed part of an ancient land-surface during the greater part of the Eocene period. Then came a subsidence of this land beneath the sea, and in this sea were deposited the sandstones of the Kythræan Series, which is referred to the latest part of the Eocene period.

The absence of fossil remains in the older strata led some Continental geologists to believe that their deposition took place at so great a depth under the sea as to be below the zone of life,

presumably in Mediterranean waters; but so far as the Kythræan beds are concerned this is disproved by the discovery of tests of Globigerina in a slice of Macigno by Mr. Jukes-Browne. The gritty material of these calcareous sandstones is, however, of volcanic origin; they may, in fact, be accumulations of volcanic dust and felspathic grit ejected from a volcano, and spread out over the sea-floor of the period.

The absence of organic remains in the Trypanian limestones may be accounted for by marmorosis and other metamorphic changes which have taken place since they were originally deposited.

Above the Kythræan Series come the grey Oligocene marls, containing gypsum and alabaster, and above these the white (Idalian) marls and chalks, which prove that the subsidence had continued until the water was of great depth and deposits similar to modern oceanic oozes could be formed. The subsidence was brought to an end by an epoch of volcanic disturbance accompanied by general upheaval. The Pliocene strata of Cyprus rest unconformably upon the older rocks, and moreover they belong to the younger members of that series, so that here we have a second break in the geological history of the island. During this interval, and at a time corresponding with the early Pliocene stage, the igneous rocks would appear to have emerged and the mountain ranges came into existence, only the summits of which, however, then showed above the sea, constituting groups of islands, now the Troödos Mountains on the south and the Kyrenia Hills on the north. Among these islands spread the waters of the Pliocene sea, beneath which the sandstones, conglomerates, and associated strata, all fruitful in fossil remains, were being deposited. Subsequently the waters receded and revealed the island, whose emergence may have been perpetuated in the fable of Aphrodite rising from the waves. This introduced the Pleistocene period. Later came high elevation and torrential floods, which were responsible for much of the land sculpture, and which changed the physical aspect of the country into the condition in which it is now found. May it not be assumed that this event also is still recorded in the annual ceremony of the 'Kataklysmos'?

Recent discoveries in Egypt and Syria indicate that in early Pleistocene times there existed, to the south of Cyprus, a great inland sea, leaving dry land all around Cyprus, which connected it with the mainland of Asia on the north and with Syria on the east. It was at this period that the mammalia, whose remains have recently been discovered by Miss D. M. A. Bate in the Pleistocene deposits of the caves among the Kyrenia Mountains, made their way over from the mainland. They were no doubt denizens of the great plains, now submerged, which separated the mountains of Cyprus from those of Syria and Asia Minor, and whose grazing-grounds were subsequently restricted to the estuaries of the Pedias and Yalias, where now stretch the fertile corn lands of the Eastern Mesaoria.

8. *Economics.*—The industrial uses to which the rocks of Cyprus

are put are numerous and varied, and, according to tradition, the island possessed at one time great mineral wealth, but there are now few indications of the presence of ore of any description in quality or quantity sufficient to encourage systematic mining operations.

The following are among the principal products of the rocks of Cyprus :—

Formation.	Products.
Trypanian Limestone (Cretaceous).	Marble of various kinds, formerly used by the ancients in their temples and palaces. Lime, produced at Kythræa, Dikomo, Kazaphain, etc. Clay, used for covering the flat roofs of the native houses.
Igneous Rocks.	Copper, according to tradition. The only mine now working is at Lymni, in the Paphos District. Iron pyrites in abundance. Asbestos, among the serpentines of Troödos. Puzzolana. Terre verte. Alum. Pottery earth. Gems, rock crystal or 'Papho diamonds.' Road-metal, etc.
Kythræan Series (Eocene).	Building-stone. In some localities a clay is found containing a small percentage of carbon.
Grey Marls (Oligocene).	Gypsum, for plaster of Paris. Alabaster and selenite. 'Marmoras' or paving slabs. Sulphur.
White Tabular Marls (Oligocene).	Athienou stone, for fire bricks, hearthstones, domestic utensils of various kinds. Flint, for 'dhoukanis,' a species of threshing implement. Terra umbra. Building-stone. Road-metal, etc. Mineral springs are also found issuing from these marls impregnated with sulphur.
Pliocene and Pleistocene.	Building-stone, etc. Salt, from the salt lakes of Larnaca and Limassol. The alluvial deposits of the Mesaoria are remarkable for their depth and loamy character, constituting a soil of great fertility, and eminently suited for the cultivation of cereals, etc.

REVIEWS.

I.—Palæontographical Society of London, Vol. LVIII. Issued for 1904. (London : printed for the Palæontographical Society; agents, Dulau & Co.; December, 1904.) Containing 28 pages of introductory matter, and—

1. The Fishes of the Old Red Sandstone, Part II, No. 2; by Dr. R. H. Traquair, F.R.S., F.G.S. pp. 27, illustrated with 8 plates and 10 text-figures.
2. The Cretaceous Lamellibranchiata, Vol. II, Part 1; by H. Woods, M.A., F.G.S. pp. 56, with 7 plates and 6 illustrations in the text.
3. The Carboniferous Lamellibranchiata, Vol. II, Part 3; by Dr. Wheelton Hind, F.G.S. pp. 91, with 4 plates and 3 text-figures.
4. The Inferior Oolite Ammonites, Part XII; by S. S. Buckman, F.G.S. pp. 103, with 5 plates, 140 text-figures, and 3 supplement plates of radial lines.
5. The Lower Palæozoic Trilobites of Girvan, Part II; by F. R. Cowper Reed, M.A., F.G.S. pp. 47, with 7 plates.
6. British Graptolites, Part IV; by Miss Elles and Miss Wood. Edited by Professor Lapworth, F.R.S. pp. 64, with 6 plates and 33 text-illustrations.

THE volume now issued is one of extreme interest, and is specially deserving of attention on account of the great variety of subjects dealt with in its 416 pages, illustrated by 37 quarto plates, 192 text-figures, and 3 tables of radial lines of Ammonites.

1. Dr. R. H. Traquair, the archichthyologist of the Palæozoic rocks, gives us descriptions and figures of Old Red Sandstone fishes of the genera *Pterichthys* and *Bothriolepis*, accompanying his descriptions by admirable restorations in the text, which will be of the highest zoological value to all who take an interest in these very early forms of armoured notochordal fishes, to the study of which the late Hugh Miller was one of the first to direct scientific attention and to attempt to restore.

2. Mr. Henry Woods' descriptions and figures of species of Pectens and Limas, so numerous in our Chalk formation, will prove extremely serviceable to collectors of these Cretaceous molluscs. If we compare these seven plates and text-figures with similar drawings executed 50 years ago, we cannot but be struck with the great advance made in art and the admirable quality of the illustrations now presented in these latest volumes of the Society's publications.

3. Dr. Wheelton Hind continues his work on the bivalve Mollusca of the Carboniferous period. The figures are extremely good, and the author gives carefully prepared tables of zonal and geographical distribution, which will greatly assist the work of the Committee in completing, as far as possible, their record of the life-zones of the Carboniferous rocks and the correlation of their several horizons over the British area. Few workers at palæontology in this country have displayed more energy and earnestness in carrying out their special line of scientific research than Dr. Wheelton Hind, and notwithstanding his arduous professional duties there are not many Geological Museums, or localities in the Carboniferous of Great Britain and Ireland which he has omitted to visit for study and examination.

4. Mr. S. S. Buckman gives in a Supplement to Part XII a revision of and additions to the Hildoceratidæ. The figures in the text, as well as the plates, are excellent, and will no doubt prove of service to the workers at Inferior Oolite Ammonites. In this supplement the author gives in 96 pages of text brief descriptions of upwards of 200 species referred to 51 genera of Hildoceratidæ. These are illustrated by 5 plates, containing 137 figures, 3 supplementary plates or tables of 161 'radial lines,' and 140 figures and outline figures in the text.

The labour involved in this task must have been immense, but it may be doubted whether so elaborate a system of specific determinations of a single family of Ammonites can be adopted and carried out by the ordinary museum worker or the private collector. Surely such minutiæ involve almost a specific determination and name for every single Ammonite discovered in each bed. Assuming these Cephalopods to have been gregarious in their habits, like so many other molluscs, and remembering that all gregarious species have considerable individual variability among themselves, it would seem almost as feasible to make numberless species of the slight variations in the crowds of *Buccinum*, *Fusus*, *Nassa*, and *Trochus*, or the many coloured Pectens dredged along our coast. There are, however, many entomologists (especially among the Lepidopterists) who think it lawful to make new species and even genera out of the local varieties of the butterflies which inhabit each separate valley of a single mountain range. Therefore, let the palæontologist also indulge in an outburst of species if he so pleases, but we need not follow the author any further in fissiparism than we feel disposed.

We cannot avoid touching upon one other point, namely, the very complex terms introduced by the author in his description of species, which seem calculated, like a hedge of 'prickly-pear,' to repel the student who may desire to penetrate to the hidden treasures of knowledge which lie within. Here are one or two examples of word-construction by the author, taken at random:—

Pseudogrammoceras placidum, Buckman, is described as "substeno-subleptogyral, perlatumbilicate; parvicostate to striate. (*Immature example*) . . . subplaty-subleptogyral latumbilicate" (p. cliii).

"In many genera, the concavumbilicate Ammonites, for example, and forms of the *Hyperlioceras*-type, the leptogyral species do not show expansion of umbilicus until angustumbilication has first been obtained, and often, too, not until the ribs have been lost" (p. cxliv).

The genus *Pseudogrammoceras*, S. Buckm., is defined as "subplaty-subleptogyral; latumbilicate; subdensiseptate, sublongi-sublatilobate; laterally flexiradiate; peripherally acutanguliradiate, convex to convexifastigate altisepticarinate" (p. cxliii).

These descriptions need very careful consideration and study before they are adopted.

5. Mr. F. R. Cowper Reed devotes another section of his monogragh to descriptions of the Lower Palæozoic Trilobites of Girvan, comprising species of *Asaphus*, *Illænus*, *Cyclopyge*, *Proetus*, *Bronteus*,

Lichas, etc., largely from materials furnished by Mrs. Gray, of Edinburgh, the Museum of Practical Geology, the Edinburgh Museum, the Woodwardian (Sedgwick) Museum, etc.

We wish that the author had found it possible, in cases of fragmentary specimens, such as several of these species are based upon, to have given in outline a restoration of some of the more important forms; this would have greatly enhanced the value of this very useful work, and might even now be added as a final plate, if thought desirable.

6. Miss Gertrude L. Elles and Miss Ethel M. R. Wood, aided by Professor Chas. Lapworth, continue their monograph on British Graptolites (pt. iv), dealing with the history of research and the family of the Dicranograptidæ, following with the genus *Dicellograptus* and nineteen species and varieties duly characterized and figured, then the genus *Dicranograptus* with thirteen species and varieties. These are illustrated by numerous text-figures and six quarto plates by Bemrose from drawings by Miss Wood.

In commending the work of this Society, which consists in publishing figures and descriptions of every British fossil, and has now been carried on continuously for fifty-eight years, it is hardly needful to mention that, apart from covering the bare cost of the production by artists, process-engravers, printers, etc., and for paper and other necessary expenses, the whole income of the Palæontographical Society is returned to the subscribers in the annual volumes they receive. Nay, more, owing to the greater amount than usual of plates and letterpress prepared by authors for publication in the years 1903 and 1904, the cost of these volumes has largely exceeded the Society's income for those years, so that each contributor of one guinea has really received back a volume costing the Society two guineas in return for his subscription, which has been paid for out of the small savings of past and more prosperous years. It should also be mentioned that the authors of monographs receive no remuneration whatever for their contributions, which are freely presented to the Society.

The only source for regret arises from the fact that owing to the death of many old members, and the want of a sufficiently large number of new ones coming forward to replace their loss, the income of the Society is considerably diminished, and its most valuable work will be greatly retarded in the future unless geologists, palæontologists, and biologists—indeed, naturalists generally—will unite to assist the Society to carry on its work successfully in the new year. Certainly all Literary and Scientific Institutions, Public Libraries, and private persons desirous to promote the study of palæontology should join the ranks and send in their names to Dr. Arthur Smith Woodward, F.R.S., Natural History Museum, Cromwell Road, S.W., the able and energetic Secretary, who will take care that the annual volume of the Palæontographical Society is duly delivered, carriage paid, to the address of each subscriber.

II.—Memoirs of the Geological Survey of England and Wales. The Geology of the South Wales Coalfield. Part V: The Country round Merthyr Tydfil, being an account of the region comprised in Sheet 231 of the map. By Aubrey Strahan, M.A., F.R.S., F.G.S., Walcot Gibson, B.Sc., F.G.S., and T. C. Cantrill, B.Sc. pp. viii and 132, with 2 plates and 12 figures in the text. (Wyman & Sons, 1904. Price 1*s.* 6*d.*)

THIS is the fifth part of the Memoir on the Geology of the South Wales Coalfield, and is descriptive of Sheet 231 of the New Series one-inch map. This sheet includes a small tract of the Pennant plateau and that portion of the north crop of the coalfield which extends from Dowlais to Swansea Vale. The northern half of the map is occupied by the scarps of the Lower Carboniferous rocks and by the long dip-slopes of Old Red Sandstone, which form the Fforest Fawr and lead up to the Brecknock Fans.

The Old Red Sandstone includes an upper and impersistent subdivision of grey grits and conglomerates, which is developed round parts of the Carboniferous tract. The grits pass up into the Carboniferous Limestone, and are known from fossil evidence, obtained further to the east, to be of Upper Old Red Sandstone age. The great mass of 'Brownstones' lying below the grey strata has yielded no fossils in this area, and is doubtfully referred to the Lower Old Red Sandstone. The lowest strata exposed are some green and red sandstones and marls which have been named after the Senni Valley, where they were first distinguished. One of the finest exhibitions of the characteristic scenery of the 'Brownstones' (which appear to be the backbone of the Old Red in this area) may be seen from the northern edge of Bryniau Gleision. On the far side of the deep Glyn Collwng a plateau, formed by the hard uppermost rocks, slopes gently upwards towards the north to a height of nearly 3,000 feet. Though once continuous, this long slope has been deeply trenched by stream-action into separate hill masses, each with a flat top bordered by precipitous escarpments. This is the structure of the well-known Beacons of Brecon (Pen y Fan, 2,906 feet, and Corn Du, 2,863 feet), each of which supports a small but characteristic outlier of the plateau beds consisting of well-bedded flaggy red sandstone, in which occur a few scattered quartz pebbles.

The Carboniferous Limestone Series includes the Lower Limestone Shales below the main mass of limestone, and a thin impersistent set of shales with thin dark limestones above that mass. These dark limestones towards the top of the series present the somewhat exceptional feature of weathering at the outcrop into rottenstone, which has been exploited here and there to a considerable extent, the best quality fetching £10 a ton. Analyses have been made with a view of ascertaining what has occurred in the conversion of the black limestone into rottenstone. A sample of the limestone contained about 16 per cent. of silica. "A few very small cubes of pyrites and flakes of colourless mica are the only visible impurities: there is no detrital quartz, and the silica shown in the analysis must

exist as a thin framework of chalcedonic character between the calcite grains." What has happened is that the carbonates have been removed, leaving behind siliceous matter of the above peculiar character. As much as 80 per cent. of this siliceous material is found in the best samples of rottenstone, whilst alumina and ferric oxide are in less amount than is the case in inferior samples.

In the Millstone Grit three subdivisions are made, the most conspicuous member being a massive quartz-conglomerate at the base of the formation. The fossils yielded by some shaly bands show that marine conditions prevailed during the deposition of strata of Coal-measure aspect. Upwards the Millstone Grit graduates into the Coal-measures, the upper and lower limits of the Farewell Rock being ill-defined. As regards fossils from the shales of the Millstone Grit, as many as 17 localities are given, some belonging to another sheet, whilst the species quoted include *Spirorbis pusillus*, *Lingula mytiloides*, *Orthis Michelini*, *Productus semireticulatus*, *Spirifera glabra*, two species of *Carbonicola*, *Pterinopecten papyraceus*, *Gastrioceras carbonarium*, *Gliphioceras reticulatum*, etc. Mr. Strahan observes that, as a general rule, *Carbonicola* occurs in the upper part of the shale, while purely marine forms such as crinoids, brachiopods, and cephalopods are confined to the lower part.

As regards the Coal-measures, the same author observes that the part of the North Crop included within the area under description extends from the anthracitic region of Ystradgynlais to the steam-coal region of Dowlais. While not always recognizable individually, the lower coals as a group can readily be identified in the two regions. The nine-foot seam of Dowlais and Aberdare corresponds closely in position with the nine-foot of the anthracitic region. The anthracitic region is regarded as commencing at the Vale of Neath, but there appears to be no definite boundary between it and the steam-coal area. Moreover, the anthracitisation is far from complete in the Vale of Neath, and continues to increase westwards beyond the limits of the map under description. Though all the seams are subject to the loss of bituminous matter in a west, or rather north-westward, direction, the lower seams are the first to show it. Thus, in any one vertical sinking the lower coals are on the whole less bituminous than the upper. The base of the Pennant is drawn arbitrarily at the Rhondda, No. 2 seam, which is known by another name west of the Neath. The measures in which the principal seams lie are illustrated in *vertical sections*—Sheet 83, Nos. 1, 2, 12, and 13; Sheet 84, Nos. 12, 13, and 19; and Sheet 85, Nos. 12–16.

The stratigraphy of the region is fully described, and further illustrated by a section from the Old Red Sandstone scarp to the Pennant scarp at Carn Mosyn (plate i). In addition to a large number of normal faults running in the N.N.W. direction—a system which prevails throughout the entire coalfield—there are two great belts of disturbances, known as the Cribarth and Neath disturbances, which traverse this region from E.N.E. to W.S.W. They form the forerunners of a long series of similar disturbances,

which increase in frequency and intensity towards the north-west. All have exercised a marked control upon the river-system, a fact which is well illustrated in the relation of the Tawe and Neath Valleys to the two above-named disturbances. The sections across the Vale of Neath disturbance (plate ii) present an extremely effective piece of stratigraphy.

The glacial phenomena of the region constitute not the least interesting portion of this memoir. In previous parts, descriptive of the South Wales Coalfield, reference has been made to the importance of the Brecknock Fans in this connection. The fact that the Fans formed a centre of dispersion of boulders was first ascertained about 20 years ago by Professor Edgeworth David, and one result of the recent mapping has been to confirm his conclusions in all important particulars. It is shown that the ice generated on the Old Red Sandstone plateau moved in a general southward direction, surmounting the scarps of the Carboniferous Limestone and Millstone Grit, and crossing deep valleys with little or no deflection. It failed, however, to overtop the great Pennant scarp of Carn Mosyn, but split against it, one part moving down the Cynon and Taff Valleys in a direction somewhat east of south, while another part turned south-westwards down the valleys of the Neath and Tawe. Some morainic ridges, lying at the foot of the loftier precipices, appear to have been the last work of the retreating ice-sheet; several of these enclose tarns. The Brecknock drift, near its source on the Old Red Sandstone moorland, is composed wholly of the detritus of that rock. Being an unstratified deposit, with boulders but little rounded, it is classed as a Boulder-clay, but having been derived from a formation in which arenaceous material predominates it is of a gravelly character. Southwards, within the Carboniferous area, Carboniferous boulders enter largely into its composition, the quartz-conglomerates and grits of the Millstone Grit being especially ubiquitous. In the coalfield, where shales predominate, the deposit assumes the character of a typical Boulder-clay, and the red gravelly matrix gradually gives place to a stiff blue clay. These features are well illustrated by a map (fig. 12), showing the watersheds, distribution of the drifts, and the glacial striæ. The Brecknock drift and the local drift are distinguished by different symbols, and it is interesting to note how both classes of drift have been deposited in large amounts along the northern base of the Carn Mosyn massif, a portion hanging to the Neath drainage on the south-west and a smaller portion to the Taff drainage on the south-east.

III.—Rock-Magmas as Solutions.

Die Silikatschmelzlösungen. I. Ueber die Mineralbildung in Silikatschmelzlösungen. II. Ueber die Schmelzpunkt-Erniedrigung der Silikatschmelzlösungen. By J. H. L. Vogt. Videnskr.-Selsk. Skrifter, 1903, No. 8, and 1904, No. 1.

THE analogy between igneous rock-magmas and saline solutions has been a subject of speculation since the time of Bunsen;

but it is only in comparatively recent years that the modern theory of solutions, as developed by Ostwald, Van t-Hoff, Nernst, Roozeboom, and others, has enabled the question to be treated in a precise manner. In his "British Petrography" (1888) Dr. Teall suggested that the lowering of melting-point in the mixture of two or more constituents might be applicable to rock-magmas, and that the order of crystallization of rock-forming minerals might depend upon the proportions in which they are present as compared with certain determinate (eutectic) proportions. He instanced micropegmatite as probably of the nature of a eutectic of felspar and quartz. The experimental data for putting the theory to the test were at that time lacking. They have now been in great measure supplied by Professor Vogt of Christiania. The starting-point of his work is the chemical and microscopical study of a large series of silicate-slags, more or less closely comparable in composition with igneous rocks. The results of such study, and the conclusions based on them, afford a striking illustration of the service which may be rendered to pure science by technological researches.

The first part of the memoir is essentially a comprehensive inquiry into the order of crystallization of minerals from magmas of known composition. Taking, for instance, slags consisting mainly of silicates of calcium, magnesium, and iron, without much alumina, the results are plotted on a diagram, ordinates representing acidity (i.e. the oxygen-ratio of silica to bases) and abscissæ representing the ratio *Ca* : *Mg, Fe*. Each slag corresponds thus with some point on the diagram, and the mineral which first crystallized out is noted (augite, enstatite, melilite, olivine, etc.). It is found that the points belonging to the several minerals arrange themselves in well-defined fields on the diagram. The boundaries (*Individualisationsgrenze*) between these fields represent eutectic proportions between the several constituents, and from them the percentage composition of the eutectics can be calculated. Thus, for augite and olivine the eutectic proportions are 70 : 30. From a molten slag consisting essentially of these two minerals in any other relative proportions, the one which is in excess, as compared with the eutectic, will first begin to separate.

In the second part of the memoir the lowering of melting-point in such mixtures is investigated, which gives another way of approaching the question. Here use is made of Akerman's determinations of total heat of fusion (in which the melting-point is the chief variable element); and the author has also made a series of experiments by the method of cooling, noting the temperatures at which latent heat is evolved. It is found that mixtures of two given minerals show a very notable lowering of melting-point, the greatest lowering being reached for certain definite relative proportions. These are, of course, the eutectic proportions; and the close agreement of the results with those already obtained independently by the 'individualisation' method afford a strong proof of the validity of the author's reasoning. The maximum lowering of melting-point is sometimes measured by hundreds of degrees.

Thus for olivine (melting-point 1400°), diopside (1225°), and åkermanite (1175°), the eutectic mixtures of the several pairs give melting-points—olivine-diopside 1125°, olivine-åkermanite 1030°, diopside-åkermanite 1035°; while for the ternary eutectic olivine-diopside-åkermanite the melting-point is well below 1000°.

The relations of minerals, such as quartz and the alkali-felspars, which are absent from slags, cannot, of course, be investigated by such methods; but it may be possible to obtain information in other ways. Vogt confirms Teall's view as to the significance of the micropegmatite intergrowth, and finds the eutectic proportions for felspar and quartz to be about 74 : 26. The figures seem to be very nearly the same in plutonic as in volcanic rocks; and theoretical considerations also lead to the conclusion that eutectic ratios are not greatly influenced by pressure.

An interesting branch of the inquiry is that relating to 'mixed crystals' belonging to isomorphous groups, in which the author applies the theoretical conclusions of Bakhuis Roozeboom. For mixtures of two isomorphous compounds the melting-point curve and the freezing-point curve are different. The crystals accordingly differ in composition from the magma in which they form, and they change their composition (or crystals of continually changing composition are deposited) as the process goes on. Several different types are distinguished. The author discusses especially the case of the plagioclase group, and shows why the first-formed crystals have a higher ratio $An : Ab$ than the magma from which they are formed. He discusses also the interrupted series (imperfectly isomorphous or perhaps isodimorphous) of orthoclase-plagioclase, in which the only members which can exist are those near one or the other end of the series. Here there is a eutectic ratio 40 : 60. If the ratio $Or : Ab + An$ is greater than this, orthoclase (containing more or less Ab and An) will first form; if the ratio is less, a plagioclase (with more or less Or) will form. If the magma eventually reaches the eutectic composition, orthoclase and plagioclase will separate out simultaneously; and the perthitic intergrowths are of this nature, with constant composition as regards the ratio of orthoclase to plagioclase. This part of the subject is very beautifully worked out from Lagorio's analyses of porphyritic felspars and the magmas from which they crystallized.

As regards the principal constituents of igneous rocks Professor Vogt's work seems to give a final answer to the vexed question of 'order of consolidation.' There remain the minor accessory minerals, which in general crystallize at a very early stage, although they are present only in small amount. It seems impossible to account for this behaviour by reference to eutectic proportions. Our author explains it by Nernst's law of the reduction of solubility by a common ion. This, which is a corollary of the law of mass action, tells us that spinel, for example, which has one ion (Mg) in common with other constituents of the magma, has its solubility thereby reduced, and consequently crystallizes earlier. It would be satisfactory to know more exactly in what measure this principle is

operative, and how far it may affect the mutual relations of other minerals—olivine, enstatite, augite, and biotite all having this same ion in common. Any quantitative estimate, depending on the degree of electrolytic dissociation of the several constituents, will not easily be arrived at. The author will not allow that there may be only a *limited* mutual solubility between spinel, apatite, etc., and the silicates, though he finds this kind of relation between sulphides and silicates.

We can notice here only the main features of what is virtually the outline of a consistent theory of the crystallization of igneous rocks. Many other points are touched, sometimes comprehensively, sometimes sketchily, but always in a suggestive manner. They include, for example, the important consequences of supersaturation in the magma; the modifying influence of water and other so-called 'mineralisers,' and generally the question how far results derived from the study of slags are applicable to plutonic and other natural rocks; the application of the solution-theory to magmatic differentiation; and other petrological problems. The porphyritic structure, for instance, becomes from the author's point of view a general character, not necessarily implying a discontinuous change of physical conditions between two distinct 'periods of consolidation.' The porphyritic elements may represent the excess of one or more constituents separated out at an early stage, while the ground-mass tends often to an approximately eutectic composition. This hypothesis again is examined by the test of Lagorio's analyses.

We may hope that the outline presented by Professor Vogt will be filled in by the researches of himself and other petrologists. If modifications on some minor points should be found necessary, as well as additions, this will not lessen the debt which students of igneous rocks owe to the author of the valuable memoir before us.

A. H.

IV.—An Introduction to the Geology of Cape Colony. By A. W. Rogers, M.A., F.G.S., Director of the Geological Survey of Cape Colony. 8vo; pp. xviii and 463, with a folding map and 21 illustrations. (London: Longmans, Green, & Co., 1905. Price 9*s.* net.)

THE student of South African geology, after much time spent in reading numerous Government reports, treatises, and articles scattered through different magazines, at home and abroad, usually gives up the task in hopeless bewilderment, and ends with the conviction that "nothing is but what is not." He finally develops that fatal African disease known as the sleeping sickness, when all further interest in the subject naturally ceases. At what stage, if any, geologists in this country have arrived is a matter of conjecture and is hardly likely to be known. If such an unfortunate mortal exists good news awaits him. After reading the book by Mr. Rogers he will awaken like a giant refreshed.

The present volume is the first of a series designed by Dr. Muir, the Superintendent General of Education for the Colony of the Cape

of Good Hope, to promote the study of Natural Science in South Africa, and with the consent of the Geological Commission the work was intrusted to Mr. A. W. Rogers.

The choice of author could not have been more happily made, for, in conjunction with Mr. E. H. L. Schwarz, Mr. Rogers has surveyed large tracts in the Colony during the past eight years, as well as making himself thoroughly acquainted with the literature of the subject.

The task submitted to Mr. Rogers was no easy one; but so skilful has been his performance of it that only those who have attempted to find light amidst the chaos of South African geology will realize its magnitude. Each of the many problems is adequately dealt with and yet kept in fitting proportion. The style is clear and concise, the natural result of a complete grasp of the subject. Simplicity of language, modesty of statement, adherence to fact, characterise the whole work. The descriptions are necessarily brief, but they are sufficient; there is no burdensome detail such as German writers on African geology abound in. The work of others, including that of his colleagues, receives due recognition; but the major portion of the volume really represents the results obtained by the field staff (three in number) of the Cape Geological Commission, of which Mr. Rogers is the oldest member.

The book will be found useful to many classes of readers. To those wholly ignorant of South African geology it will form a pleasing introduction; to the student, lost in the maze of conflicting accounts, it will tell what to follow and what to avoid; while the specialist, in almost every branch of geology, will find new material to illustrate and amplify the particular line of research on which he may be engaged.

In the opening chapter the author describes the chief physical features of the colony, its general geological outlines, order of the rock groups, followed by a brief but clear account of the regions occupied by the various rock formations and their tectonic relationship.

The rocks of pre-Cape age are dealt with in chapters ii–iii. The reader will here find a summary of the work done among these old rocks, the results being mainly obtained by the officers of the Cape Survey. They contain problems of a mineralogical, petrological, stratigraphical, and dynamical character, many of them of worldwide interest, and of especial importance in connexion with the age and succession of the older rocks of other parts of South Africa. Wisely enough, however, the author makes no attempt to force a correlation, either between the two areas in which this complex of rocks occurs in Cape Colony or with the far distant region of the Transvaal. We are pleased to see references to, and ample recognition of, the admirable researches of G. W. Stow in Griqualand West.

The question of the order of the succession of the different members of the Cape System (Table Mountain Sandstone, Bokkeveld, and Witteberg Series) and their relationship to the pre-Cape rocks is discussed, in conjunction with a description of the rocks, in chapter iv.

The classification of A. G. Bain is adhered to. The figures of fossils from the Bokkeveld beds are a welcome addition.

The Karroo formation, forming unquestionably one of the best known rock groups in South Africa, receives full attention. It is somewhat startling to read that at present there is no very satisfactory classification of these rocks. The chapter by Professor Groom on the reptiles of the Karroo formation will therefore be of much value, for, as is well known, these animals mark distinct horizons. As is fitting, considerable attention is paid to the intrusive dolerites and allied rocks of the Karroo system, for besides being a distinctive feature of the Karroo country they present problems the petrologist has not solved. The author does not support the absorption theory for the intrusive masses of Pondoland and East Griqualand. Plate xvi, showing columnar structure in Dwyka conglomerate produced by an overlying sheet of dolerite, might readily be used to controvert the knowing.

The knowledge of the rocks of the Cretaceous system is brought up to date in chapter viii. Good illustrations of the typical fossils are given, while Dr. F. L. Kitchin supplies notes on the relationship of the marine fossils to those of foreign Cretaceous faunas. The chapter on the volcanic pipes younger than the Stormberg Series (summit of the Karroo) includes a short account of the diamond pipes of the Kimberley area. The author considers that these great explosions occurred "at some period after the close of Stormberg times (probably after the Uitenhage period)."

A chapter on the Recent deposits, including that of the vleys and pans, concludes the detailed description of the geology. It is followed by a summary of the geological history of the colony. Subjects of a more speculative character are here dealt with, among which we note that the period of great mountain-building in South Africa succeeded the Ecca beds (Permo-Carboniferous) and occurred somewhere between this and the Uitenhage (Lower Cretaceous) period, possibly between the Ecca and Beaufort (Permo-Triassic) periods.[1]

Each of the chapters forms a treatise in itself, and the reader interested in any particular formation will readily find what he seeks, while for fuller detail he is referred to the standard works given in the appendix.

The volume is illustrated throughout by numerous plates of admirably reproduced photographs of rock scenery and rock structure. The figures of fossils are clearly drawn. The horizontal sections are somewhat meagre and not impressive, owing to the necessarily small scale adopted for the vast distances represented. On the coloured geological map, which is clearly printed, the number of place-names is far too small. A few topographical maps would materially assist the reader. The notes on the geology of some of the railway lines given in chapter xii seem out of character with the rest of the work, and would be better as an appendix. The book needs a more copious index.

[1] Age given in the brackets is ours.

Some critics will probably find fault with the comparatively brief notices given of economic products. In a country of which the geology is so little known nearly the whole book becomes of economic importance. The geology of Cape Colony affords the key to the rock structure of South Africa, and therefore to its mineral wealth. Every engineer, miner, or prospector in South Africa, and those being trained in this country for the colony, should therefore make themselves fully acquainted with the main facts contained in this book, and thoroughly master the many problems so ably and clearly presented by Mr. Rogers. WALCOT GIBSON.

REPORTS AND PROCEEDINGS.

I.—GEOLOGICAL SOCIETY OF LONDON.

February 1st, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair.

Professor Garwood exhibited and commented on a set of twelve lantern-slides illustrating the use of three-colour photography in demonstrating the microscopic characters of rock-forming minerals in polarized light. The slides were taken by the Sanger-Shepherd process, in which yellow, green, and red screens were used. He said that it was not a process that could be used very easily, but one which required a good deal of time to produce really accurate prints. Considerable difficulty was experienced in procuring objectives which were truly corrected for the spectrum, the tendency in the case of interference figures being to give different-sized rings for different colours. The results did resemble very closely the phenomena seen under the microscope; and he had brought one or two rock-sections shown on the screen, in case Fellows interested in the subject would like to compare the slides with the original sections.

The following communication was read:—

"On the Sporangium-like Organs of *Glossopteris Browniana*, Brongn." By E. A. Newell Arber, M.A., F.L.S., F.G.S.

It has been discovered that some specimens from New South Wales, on which numerous and well-preserved scale-fronds of *Glossopteris* occur, also exhibit impressions of groups of minute bodies, not unlike the sporangia of certain recent and extinct Ferns and Cycads. The new organs are elliptical in shape, and measure from 1·2 to 1·5 millimetres along the major axis. They are hollow, sac-like structures, which open or dehisce longitudinally. Unfortunately no trustworthy evidence can be obtained as to their contents. The fact that they have never been found, except in the closest association with the scale-leaves of *Glossopteris*, is regarded as an indication that they may be attributed to that genus; and this conclusion is supported by the direct evidence of some of the scale-fronds, which show scars of attachment and fragments of the

sac-like bodies still apparently in continuity. While, in the absence of recognition of spores, it is impossible to be quite certain that these sac-like bodies are really sporangia, there is much to be said in favour of this conclusion. The fact that they were probably borne on the scale-fronds in sorus-like groups, and that in size, shape, and mode of dehiscence they are not unlike the sporangia of certain recent and fossil plants, supports this view. The closest analogy may probably be found in the microsporangia of Cycads, which are also exannulate.

A historical sketch is given of the present evidence on the subject of the fructification of *Glossopteris*; and it is shown that no sporangia have so far been found, and that such evidence as has been put forward as to the occurrence of sori on the larger fronds is not altogether satisfactory. It is pointed out that, if the present conclusion be correct (that the sporangia were borne on the smaller scale-fronds), *Glossopteris* cannot be included in any recent family of the true Ferns. Although the affinities of this genus are still doubtful, the creation of a new family may not be inadvisable.

II.—Edinburgh Geological Society.

January 18th, 1905.—James Currie, M.A., F.R.S.E., President of the Society, in the Chair.

The following papers were read :—

1. "Notes on a Journey through British North Borneo." By Mr. Andrew Burt.

Mr. Burt gave a sketch of a journey he had made through North Borneo, and described its position, climate, and products. He spoke chiefly of the coal-mines in Labuan and Sarawak, which, he explained, had to be worked by Chinese and Malay labour, the natives being practically useless as workmen.

2. "Notes on the Pre-Glacial River System of the Forth." By Mr. H. M. Cadell, B.Sc., F.R.S.E.

Mr. Cadell described various places where ancient buried river valleys had been proved by mining to exist at considerable depths below the present surface, and said it was highly important from a mining as well as a geological standpoint to be able to locate these drift-filled gullies of ancient 'wash-outs.' There was a deep glen under the Carron Water, which entered the Forth at Grangemouth, at a depth of 270 feet below the sea; and another below the Almond, which had been traced northward from Mid-Calder for eight miles, and ran seawards under Dalmeny Park at a depth of more than 100 feet. Between Preston Island and Culross, again, there was under Torry Bay an ancient trough, which had been struck in the coal workings on Preston Island in 1811 at a depth of 46 fathoms. This was no doubt a part of the ancient Forth Valley in pre-Glacial times. The deepest of the buried valleys that had hitherto been discovered by boring was the ancient gorge or canyon of the Devon, which at Glenochil Distillery had been found by boring to be over 370 feet deep, and filled with mud,

sand, and clay. These ancient valleys all proved that when they were scooped out by swift rivers the land was much higher than it is now. Mr. Cadell went on to discuss this conclusion, and he showed that if the gradient of the ancient Forth was 25 feet per mile, the glen must have been 1,000 feet deep at the Forth Bridge, and the North Sea bed was a great plain. He exhibited interesting panoramic sketches he had painted, showing what he imagined was the scenery of the Forth Valley at that period where the islands of the Firth were the tops of rocky pinnacles, and hairy elephants, bears, and wolves roamed through the forests of the pre-Glacial continent, before Britain was an island.

III.—Mineralogical Society.

January 31st, 1905.—Professor H. A. Miers, F.R.S., President, in the Chair.

Mr. H. H. Thomas gave a detailed account of the crystallographic, optical, and chemical characters of epidote found in a vein in gneiss, near Barrisdale, Inverness-shire. A chemical analysis made by Dr. Pollard showed that the mineral contained a very low percentage of ferric oxide (6·81). In this respect it was similar to epidotes from Huntington, Mass., and the Zillerthal, and like them showed correspondingly low refractive and double refractive power and large optic axial angle, as compared with epidotes containing higher percentages of iron.—Mr. T. V. Barker communicated a preliminary note on the regular growth of crystals of one substance upon those of another. The observations of previous investigators were in general confirmed with regard to the growths of K I, K Br, K Cl, and $Na\,No_3$ upon mica, and of $Na\,No_3$ upon calcite. In all cases a clean surface is necessary. Attempts to get a regular deposition of $Na\,No_3$ upon other rhombohedral carbonates of the calcite group and upon dolomite were without any positive result, although the rhombohedral angle of some of them is much nearer to that of $Na\,No_3$ than is that of calcite. The topic axes, however, are in order of magnitude as follows: $Na\,No_3$, calcite, rhodochrosite, dolomite, chalybite, so that if the regular growth depend on the fitting together of similar structures the experiments point to the usefulness of the conception of topic axes. The author is continuing his observations.—Mr. K. A. K. Hallowes described an apparatus for determining the density of small grains. The method is by hydrostatic weighing, and the grain is held under water (or preferably alcohol) in a spring-clamp, made of brass wire and two cover-glasses, which is suspended from the beam of the balance by a fine hair.—Professor H. A. Miers exhibited a specimen of massive danalite from Wheal Maudlin, a new locality for this mineral in Cornwall, and also a crystal of barium-radium bromide, the crystallographic characters of which he also described. Mr. Arthur Russell exhibited a specimen of phenacite and one of aurichalcite from Cornish localities, and Mr. H. F. Collins specimens of sulphide of lead and oxide of zinc artificially produced in furnaces at Laurium.

CORRESPONDENCE.

'DEUTOZOIC.'

SIR,—I can extract no other meaning from Mr. Goodchild's defence of the term 'Deutozoic' than this: that when next I am in a geological difficulty—say, about the age of the earth—I should refer the question to any eminent Professor of Theology, and submit to his decision. T. G. BONNEY.

CREEP-FOLDING IN VALLEY BOTTOMS.

SIR,—When I read in "*Water*," vol. vi, p. 491, an account of a paper by Professor Boyd Dawkins dealing with the effect of relaxation of pressure in causing folds in the rocks at the bottom of valleys I thought I had come across what was no more than a reporter's error, repeated in the GEOLOGICAL MAGAZINE, December, 1904, p. 618. Since, however, an almost identical statement appears in the Proceedings of the Manchester Lit. and Phil. Soc., vol. xlix, p. 8, I presume that it correctly represents Professor Dawkins's views on the subject.

The folding in the strata at the bottom of the Don and Derwent Valleys is held by the author to be "analogous in every particular" to 'creep' in coal-workings; and he goes on to say: "This may be studied in any coal-pit where there is a superincumbent pressure, say, of more than 1,000 feet." Now, the maximum pressure available at the Howden and Derwent dams is due to no more than 900 feet: moreover, this maximum pressure is only reached at a distance of $1\frac{1}{2}$ miles from the valley, and is increasingly reduced as the latter is approached.

It cannot be contended that the removal of "at least 9,700 feet" of rock from above the site of the dams has had anything to do with the folding in the valley bottom, and yet it is difficult to see for what other purpose these figures are introduced except to lend support to the theory.

There is not the slightest evidence to show that the Derwent Valley was ever deeper than it is now; but if Professor Dawkins's figures mean anything they imply *a valley 9,700 feet deep with the stream on its present bed.* J. ALLEN HOWE.

MUSEUM OF PRACTICAL GEOLOGY,
LONDON.

OBITUARY.

PROFESSOR JOSEPH P. O'REILLY, C.E., M.R.I.A.

BORN JULY 11, 1829. DIED JANUARY 6, 1905.

BY the death of Joseph P. O'Reilly, lately Professor of Mining and Mineralogy at the Royal College of Science, Dublin, yet another link with the older generation of Irish geologists and archæologists has been severed, as also the ties of friendship which existed

between him and all those who came in contact with his charming personality. To none will the news of his death come with greater feelings of regret, than to his former pupils, amongst whom the writer is glad to be able to number himself.

As a teacher, Professor O'Reilly possessed the comparatively rare distinction of being able to make lectures on Mineralogy interesting, as well as instructive. A strong advocate of the use of the blackboard for demonstration purposes, he largely availed himself of this method of teaching, for which indeed his really fine draughtsmanship eminently fitted him. The beautiful perspective representations of the more complicated crystal forms, which he drew with surprising rapidity and accuracy on the blackboard, are not likely to be ever forgotten by those who, under his ægis, were first introduced to the science of crystallography. His concern for his students did not end with the lectures; he took a personal and kindly interest in each, and was ever ready with his help and advice both during and after their college career.

The fifth son of the late Thomas Reilly, Taxing Master in Chancery in Dublin, Professor O'Reilly was born in the town of Monaghan in 1829. Owing to the absence of facilities in Ireland, at that time, for learning the science of civil engineering, he went to Paris and studied for some years, at the Ecole Centrale des Arts et Manufactures, obtaining the Engineering diploma of that institution in 1855, and incidentally getting his first instruction in geology and mineralogy.

In 1856, he obtained the appointment of engineer to a French mining company, then engaged in exploiting the newly discovered zinc-mines of Santander in Spain. Later he was engaged by a second French company, who were working the deposits of sulphate of soda in the Jarama valley near Madrid. Returning to Ireland in 1863, he published the results of his geological investigations in the foregoing districts, in a series of papers written in conjunction with the late Dr. W. K. Sullivan. He became subsequently connected with the Mining Company of Ireland, at the time when the Silvermines district in Tipperary was being extensively worked. In 1868 he was appointed Professor of Mining and Mineralogy at the Royal College of Science for Ireland, a position which he held till the year 1899. In addition he held the post of Secretary in the same college from 1881 to 1894. He was also President of the Royal Geological Society of Ireland, in the year 1885; Vice-President of the Royal Irish Academy from 1886 to 1889, and again from 1901 to 1904; and acted as extern examiner in geology to the Royal University of Ireland, for several years.

His published contributions to the literature of Irish geology, mineralogy, and archæology were very numerous, altogether some sixty in number. A full bibliography will be given in the *Irish Naturalist* for March, and hence they need not be individually mentioned here. His geological papers dealt mainly with earthquakes and volcanic phenomena, and also with rock-joints, and their influence on the direction of coastlines. These papers, which were

usually voluminous, betray an immense amount of painstaking work, such as few would care to undertake. As an instance, his catalogue of British and European earthquakes, which covers some 250 quarto pages, in the Transactions of the Royal Irish Academy (vol. xxviii) may be mentioned. After retiring from his professorship in 1899, his papers were mainly on archæological subjects, and were chiefly descriptive of some of the older ecclesiastical remains in the neighbourhood of Dublin.

Since the year just mentioned, no less than ten papers were written and published by him; he was, in fact, working up to and actually on the very day of his death, which took place suddenly on the evening of the 6th of January of the present year.

HENRY J. SEYMOUR.

THOMAS WILLIAM SHORE, F.G.S.

BORN APRIL 15, 1840. DIED JANUARY 15, 1905.

WE regret to record the death of Mr. T. W. Shore, who for many years was Curator of the Hartley Institution at Southampton, and one of the founders and Organising Secretary of the Hampshire Field Club. Mr. Shore was much interested in local geology and archæology, and was one of the secretaries of Section C of the British Association at the Southampton meeting in 1882, for which meeting he prepared the local guide.

He was the author of articles on "The New Dock Excavation at Southampton," with J. W. Elwes (1889), "The Clays of Hampshire and their Economic Uses" (1890), "Springs and Streams of Hampshire" (1891), "Hampshire Mudlands and other Alluvia" (1893), "Hampshire Valleys and Waterways" (1895); all published in the Papers of the Hampshire Field Club.

On retiring from the Hartley Institution, he settled at Balham, near London, and devoted himself more especially to antiquarian work. He assisted in founding the Balham Antiquarian Society, of which he was Secretary, and he was also Secretary of the London and Middlesex Archæological Society.[1]

PROFESSOR GEORGE BOND HOWES, LL.D., F.R.S.

BORN SEPTEMBER 7, 1853. DIED FEBRUARY 4, 1905.

BIOLOGICAL science has sustained a heavy loss by the death of Professor G. B. Howes, whose high scientific attainments, coupled with an exceeding amiability of character and ever ready disposition to assist those who needed his help in their work, had endeared him to a wide circle of friends and students.

George Bond Howes was born in London in 1853; he was the eldest son of the late Thomas Johnson Howes, and was educated at a private school. He entered the Biological division of the Royal School of Mines in 1874 under Professor Huxley. In 1881 he was

[1] We are indebted for some of the above particulars to the *Times*, Jan. 17, 1905.

made Demonstrator in Biology in the Normal School of Science, and in 1885 Assistant-Professor. Professor Huxley in that year was compelled by ill-health to resign all his public offices, only retaining his connection with the Normal School of Science and Royal School of Mines as Dean and honorary Professor of Biology. On Professor Huxley's death in 1895, Dr. Howes was appointed his successor as Professor of Zoology. He was formerly Lecturer on Comparative Anatomy to St. George's Hospital Medical School, and for several years was one of the Examiners in Biology to the University of London; a Vice-President and member of Council of the Zoological Society of London; Hon. Zoological Secretary Linnean Society; ex-President of the Malacological Society; and President of Section D, British Association in 1903. Dr. Howes was widely known by his "Atlas of Practical Elementary Biology," and by his papers on the morphology and physiology of the Vertebrata, both recent and fossil. He was joint editor with Dr. D. H. Scott of a revised and extended edition of Huxley & Martin's "Course of Practical Instruction in Elementary Biology."

His death at the comparatively early age of 51 years was doubtless accelerated by a combination of unfortunate accidents, which acting upon a highly nervous organisation proved too severe for his delicate constitution to sustain. He leaves a wife and daughter to deplore his loss.

MISCELLANEOUS.

Dover Coal-boring.—It is satisfactory to learn that "At last the dogged perseverance of those who direct the policy of the Consolidated Kent Collieries Corporation (Limited), on whose shoulders have fallen the mantles of several Kentish coal companies, has been rewarded, and a workable seam of bituminous coal, one foot eight inches thick, has been 'struck.'" We quote these words from the *Morning Post* of February 4th. It will be remembered that a boring at Dover in search of coal was commenced in 1886, and the discovery of coal was announced in 1890. The present record of "'Black Diamonds' at last" is simply the confirmation of the evidence obtained in the original boring by the sinking of a shaft through the same series of strata to a depth of 1274 ft. 10 ins. A coal-seam found in the original boring carried out by Mr. F. Brady has now been struck in the shaft at practically the same level, and about 12 tons of good coal have been raised. It is stated that a second shaft must be sunk before the coal can be worked. There is a second shaft which is over 600 feet deep, but it is calculated that at least two years must elapse from the time the plant has been secured before this shaft can be completed. Meanwhile the present shaft must be sunk more than 500 feet deeper to reach other seams proved in the original boring. From a geological point of view the prospect is encouraging.

THE

GEOLOGICAL MAGAZINE.

NEW SERIES. DECADE V. VOL. II.

No. IV.—APRIL, 1905.

ORIGINAL ARTICLES.

I.—Devonian Fossils from the Parish of St. Minver, North Cornwall.

By Howard Fox, F.G.S.

I CONTRIBUTED a paper to the April number of the Geological Magazine for 1900 on the geology and fossils of the Devonian rocks on the north coast of Cornwall, *south* of the River Camel. In the present communication I propose to notice a series of fossils which I have lately obtained from the slaty rocks of Devonian age in the parish of St. Minver on the *north* of the Camel, which, from Trewornan, one mile north of Wadebridge, for the lower five miles of its course as river and estuary, forms the southern and south-western boundary of this parish. The open sea-coast forms its northern and north-western boundary, extending from the easterly limit at the Cove of Port Quin, the site of an old but now forsaken fishing village, about eight miles south-west of King Arthur's Castle, Tintagel, westwards round the basaltic cliffs of Pentire Head, and thence in a southerly direction to the estuary of the Camel.

The fossils generally occur partially weathered out on the surface of the slates of the low cliffs and beaches along the coastline and estuary. We propose first to refer to the principal localities where they have been obtained, beginning at Port Quin and following the northern and western coastline to the estuary, and then eastward, along the southern boundary to Trewornan. The names of the places mentioned will be found on the 6 inch maps of the Ordnance Survey.

The first locality west of Port Quin where fossils have been found is at the small cove of Epphaven, about a mile distant. In bluish slates at this place a fragmentary Ophiurid (Brittle-star) was obtained by Miss Barbara Legg in 1902. The specimen has been described and figured by Dr. Bather under the name of *Sympterura Minveri*, n. g. et sp., in the accompanying paper. The same slates also contain detached crinoidal stem-joints and minute spine-like bodies referred to *Styliola*.

To the west of Com Head, in slaty boulders on the beach and in the cliffs, small branching corals, belonging to *Pachypora*, and crinoidal fragments are occasionally met with.

On the south side of Pentire Point, and immediately west of Pentire Haven, there are several caves, floored with bright shingle, known as the 'Gravel Caverns.' Seaward of these caves there are three large masses of conglomerate conspicuous from the bright pebbles of which they are largely composed, and beyond these seawards several beds of the same kind of rock may be seen when storms have partially removed the loose beach material which usually covers them. Another bed of this rock is also visible, forming a ledge at the base of the cliff north of the Gravel Caverns towards Pentire Point. The conglomerates, and the slates in contact with them, contain fragments of fossil wood, branching coral, *Pachypora* sp., crinoidal joints, *Cardiola retrostriata*, *Orthoceras* or *Bactrites*, and small Goniatites. The molluscan remains are usually pyritized.

From Pentire Haven we pass southward for some miles, coasting the cliffs of Pentire Glaze Haven, Polzeath, Trebetheric Point, and Daymer Bay, till we reach the igneous rocks of Bray Hill. The cliffs are composed of beautifully banded, purple, green, grey, and buff slates which De la Beche[1] classed in error with the variegated Lower Devonian slates of Watergate Bay, further to the south. No fossils have as yet been met with in these northern variegated slates.

The village of Rock, to which the ferry-boat from Padstow plies, is at the northern boundary of a range of shore-line which extends in a south-easterly and easterly direction, forming the north bank of the Camel, as far as Trewornan at the eastern corner of St. Minver parish. Along this shore beds of slate, limestone, and various igneous rocks, including volcanic lavas and tuffs, are exposed. The slates are very strongly cleaved, so that it is difficult oftentimes to distinguish bedding and cleavage and to determine their strike. In places they are very fossiliferous, and not infrequently the fossils are in better preservation than those hitherto found in the rocks south of the Camel. This fossiliferous coast area may be considered more conveniently in the following divisions:—

1. *Porthilly Cove, i.e. from Rock to Porthilly Point.*

Some of the slates contain numerous specimens of minute *Styliola*, whilst in other slates of a blue or brown colour, in the neighbourhood of igneous rocks, cup-corals and crinoidal remains are present, but they are very poorly preserved.

2. *Porthilly Point to Gentle Jane or Cant Hill.*

In the low cliffs south of Porthilly Point there are black nodules containing fragments of *Conularia*, and beyond these, in a series of old slate quarries, cup-corals, crinoidal remains, *Styliola*, and casts of small doubtful Brachiopods or Lamellibranchs are present. Casts

[1] Report on the Geology of Cornwall, etc., p. 91.

of *Pleurodictyum* are plentiful; on one loose slab of slate, 3 feet by 2½ feet, four colonies were found; some of the specimens are in very fair preservation. Near the eastern end of this section, two small Trilobites were found in blue slates on the foreshore: they have been referred by Dr. H. Woodward to *Phacops latifrons*.

3. *Gentle Jane or Cant Hill to Cant Cove.*

The beach at Gentle Jane, like most of those along these foreshores, is composed of worn fragments of blue slate, with hardly any admixture of quartz pebbles or sand. It is situated at the western end or foot of a long flat-topped hill, 247 feet in height, composed for the most part of volcanic lavas and tuffs (Schalstein). The slates of this range of shore become increasingly fossiliferous as the igneous rocks are approached. About 300 yards from Gentle Jane the slates are nodular and contain casts of Cephalopods, which are described by Mr. G. C. Crick in the annexed paper. They belong to *Orthoceras*, *Cophinoceras*, and *Agoniatites*.

To the east of the area characterized by the predominance of Cephalopods there are three exposures of igneous rock, and about 150 yards beyond the last of these there are some nodular grey, greenish, and buff slates, in which, with some Polyzoa and other fossils, a fair number of Trilobites belonging to the genus *Phacops* are present. Some of these are in good preservation, and retain the facetted structure of the eyes in fairly perfect condition.

Yet further eastwards the foreshore is covered to a varying extent with rounded fragments of lava and tuff similar, Mr. Ussher informs me, to the Schalstein of Drake's Island, Plymouth, and other localities in Cornwall and Devon. Some of the slates interbedded with the Schalstein are filled with fossils which are now for the most part decomposed to a bright red rust, and consequently in a very fragile condition.

This tract of foreshore included in the term of 'Cant Hill' is by far the most prolific in the area of St. Minver, both in the number and variety of its fossils, and in addition to the genera already mentioned as occurring in it the following are also represented: *Petraia*, *Zaphrentis*, *Cyathophyllum*, *Amplexus*, *Favosites*, *Alveolites*, *Pleurodictyum*, *Monticulipora*, *Fenestella*, *Polypora*, *Phyllopora*, *Atrypa*, *Spirifer*, *Pentamerus*, *Rhynchonella*, *Orthothetes*, and *Conularia*. Crinoidal remains are also plentiful, but they cannot be assigned to any particular genus.

4. *Cant Cove to Dinham Creek.*

Rounding Cant Cove, we find on the shore to the east pale grey slates from which were obtained *Styliola*, *Polypora*, and a well-preserved and interesting small Trilobite, which Dr. H. Woodward has figured and referred to *Phacops granulatus*, Münster. A fairly perfect cast of an *Orthoceras*, figured and described by Mr. Crick as near to *O. hercynicum*, was also found in these slates. Crinoidal stem-joints are likewise common.

Igneous rocks are present on both sides of the entrance to Dinham Creek, whilst at the inner end of the creek, south of the bridge crossing the stream, there are several beds of limestone. These have been noted by De la Beche on the Survey Map.

5. *Dinham Creek to Trewornan.*

In this tract of the shore the only fossils met with are *Styliola*, the cast of a small Gasteropod, and several fragmentary specimens of *Orthoceras*, which have been referred by Mr. Crick to *O. nassoviense*. Foord, *O. gracile*, Blum., *O.* sp., intermediate between *O. rapæforme*. Roem., and *O. subconicum*, Roem., and a fragment of a *Bactrites*. The low cliffs extending for about half a mile to Trewornan are composed of variegated unfossiliferous slates similar to those in the cliffs between Pentire Haven and Rock.

LIST OF FOSSILS FROM ST. MINVER.

Hitherto no list of the fossils from this particular area appears to have been published, and it seemed therefore desirable to prepare one which would be of service in comparing with the fossil faunas from other parts of Cornwall, and also throw some light on the particular horizon of the Devonian series to which they may be referred. Not having the special knowledge or the requisite opportunities for determining the fossils myself, I have again had recourse to the assistance of my palæontological friends who have helped me in past years, and desire here to express my great obligations to Dr. H. Woodward, F.R.S., who has described the Trilobites, to Mr. G. C. Crick, F.G.S., for the determination of the Cephalopods, to Dr. F. A. Bather, F.G.S., for the description of the new Ophiurid, to Dr. C. A. Matley, F.G.S., who had examined the Brachiopoda, and to Dr. G. J. Hinde, F.R.S., for the list of the Corals and Polyzoa.

Actinozoa.

Petraia spp. Casts of small cup-corals, probably representing two or more species. Common at Cant Hill, east of Cant Cove.

Zaphrentis sp. Depressed conical, at summit 20 mm. wide, 20 principal septa, well-marked fossula. Cant Hill.

Amplexus (?) sp. Compound, branching, the branches diverge from a common stock, about 10–15 mm. in diameter and about 150 mm. in length. Septa about 40, their interior characters not shown. Cant Hill.

Cyathophyllum sp. Cylindrical, 5–6 mm. in diameter, about 36 septa. Cant Hill. Rare.

Favosites sp. A small fragment on a slab with *Atrypa reticularis*. Cant Hill.

Alveolites sp. Plate-like growths, some measuring 70 mm. by 50 mm., walls replaced by rusty material, corallites about 0·5 mm. in width. Cant Hill. Common.

Pachypora sp. Branching form, the branches about 5 mm. in diameter, and the corallites about 0·5 mm. wide. West of Com Head.

Pachypora, sp. *a*. Fragment of a branching specimen, the branches 10 mm. in diameter, corallites round or oval, 0·8 mm. wide. Gravel cavern conglomerate, south of Pentire Point.

Pleurodictyum sp. The same forms as those from Constantine Bay, Porthcothan Cove, and other localities, described in GEOL. MAG., Dec. IV, Vol. VII (1900), p. 151, Pl. VII, Fig. 11. East of Porthilly and Cant Hill. Common.

OPHIURIDEA AND CRINOIDEA.

Sympterura Minveri, Bather. (See accompanying paper.) Epphaven.

Crinoidea. Stem-joints, usually as casts. Epphaven; west of Com Head; south of Pentire Head, in conglomerate; Porthilly Cove; south of Porthilly Point; Cant Hill; east of Cant Cove. Common.

TRILOBITA.

Described by Dr. H. Woodward. (See accompanying paper.)

Phacops latifrons, Bronn. Cant Hill. Common.

,, *granulatus*, Münster. Cant Hill; east of Cant Cove. Common.

,, (*Cryphæus*) *punctatus*, Steininger. Cant Hill.

,, (*Trimerocephalus*) *lævis* (?), Münster. Cant Hill.

POLYZOA.

Monticulipora (*Monotrypa*) sp. A small fragment, encrusting, cells about 0·25 mm. broad. Cant Hill.

Fenestella, sp. *a*. Polyzoary fan-shaped, branches straight, closely set, 0·5 mm. in width, fenestrules oval, 0·5 mm. in length, 2–3 zoœcia between each dissepiment, apertures prominent and thickened. Cant Hill.

Fenestella, sp. *b*. Only a small part of the upper face shown. Branches narrow, 0·3 mm. in width, keel prominent, fenestrules subangular, about 0·8 mm. in length, 2–3 cells between each dissepiment. Cant Hill.

Polypora sp. Fragment. Branches 0·5–0·7 mm. broad, fenestrules oval, 1 mm. long by 0·5 mm. wide, 3–4 rows of cells. East of Cant Cove.

Phyllopora sp. Fragment. Branches inosculating, 0·5–0·8 mm. in width, 3–4 rows of cells, alternating, fenestrules elongate, irregular. Cant Hill.

BRACHIOPODA.

The Brachiopods have been kindly examined by Dr. C. A. Matley, who reports that, owing to the fact that many of the specimens are only casts and these often crushed and distorted, their exact identification is very difficult, and the names given to them should, therefore, with some exceptions, be considered as approximations rather than certainties.

Orthothetes crenistria (?), Phill. Fragments only. Cant Hill.

Orthothetes (?). Cast of interior; the characters are peculiar, and the genus cannot satisfactorily be defined. Cant Hill.

Atrypa reticularis, Linn. A single specimen, well preserved. Cant Hill.

Atrypa cf. *desquamata*, Sowerby. Dr. Matley states: "I am doubtful, as there are some peculiar ridges in the interior of both valves (shown in the internal casts), which I have not met with before in this genus." This is the commonest form; ten specimens were obtained, the majority are casts. Cant Hill.

Spirifer sp. The nearest species to this seems to be *S. cultrijugata*, Roemer, but this appears to be quite distinct. Cant Hill.

Spirifer sp., cf. *S. speciosa*, Schl. A single specimen. Cant Hill.

Pentamerus (? *Gypidula*) *brevirostris*, Phill. An internal cast. Cant Hill.

Rhynchonella (*Camarotœchia*) *laticosta*, Phill., ? var. There are only 4 ribs on the fold. An internal cast. Cant Hill.

Lamellibranchiata.

Cardiola retrostriata, Von Buch. Pyritised casts. Gravel conglomerate. South of Pentire Point.

Pteropoda.

Styliola sp. Epphaven, Porthilly Cove, west and east of Dinham Creek.

Conularia subparallela, Sandberger. Cant Hill.

,, sp., cf. *C. deflexicosta*, Sandberger. Porthilly, Cant Hill.

Cephalopoda.

Described by Mr. G. C. Crick. (See accompanying paper.)

Orthoceras cf. *hercynicum*, Kayser. East of Cant Cove.

,, cf. *commutatum*, Giebel. Cant Hill.

,, *nassoviense*, Foord. East of Dinham Creek, Trewornan.

,, cf. *O. rapæforme*, Roem., and *O. subconicum*, Roem. East of Dinham Creek.

,, *gracile*, Blum. Trewornan.

,, or *Bactrites*. Conglomerate. Gravel Caverns, south of Pentire Point.

Bactrites sp. Trewornan.

Cophinoceras sp. Cant Hill.

Phragmoceras (?) sp. Cant Hill.

Tornoceras sp. Conglomerate. Gravel Caverns.

Agoniatites sp. Cant Hill.

Although the specific characters of many of the fossils in the above list cannot be recognized owing to their imperfect preservation, there appears to be sufficient evidence to justify the conclusion that, whilst the Gravel Caverns conglomerate and the slate rocks forming the banks of the north shore of the Camel estuary in the Porthilly and Dinham Creek districts are Upper Devonian, those in the intermediate and more southern region of Cant Hill may be Middle Devonian in age.

II.—Notes on a series of Trilobites obtained by Mr. Howard Fox, F.G.S., from the Devonian of Cant Hill, St. Minver, Cornwall.

By Henry Woodward, LL.D., F.R.S., F.G.S.

(Plate V, Figs. 1–5.)

In September of last year I received from Mr. Howard Fox, F.G.S., of Falmouth, nine specimens of Trilobites for the purpose of determination and description. They are all more or less fragmentary, and distorted by slaty cleavage, as is usually the case with fossils from these Devonian Slates of Cornwall and Devon, reminding one of the distorted Trilobites and Starfishes from the Lower Devonian Slates of Bundenbach, Germany.

I subjoin a list of the specimens received and my notes thereon, which I hope may prove acceptable to my friends in Cornwall.

1. *Phacops latifrons*, Bronn: Cant Hill, St. Minver, North Cornwall.
2. ,, (*latifrons*?) ,, ,, ,, ,,
3*a*, *b*. ,, *granulatus*, Münster: east of Cant Cove, north shore, North Cornwall.
4. ,, ,, ,, Cant Hill, St. Minver, ,,
5. ,, ,, ,, ,, ,,
6. ,, (*latifrons*?) ,, ,, ,,
7. ,, *punctatus*, Steininger: ,, ,, ,,
8. ,, *lævis* (?), Münster: ,, ,, ,,
9. ,, *latifrons*, Bronn: ,, ,, ,,

1. Phacops latifrons, Bronn. (Plate V, Figs. 1*a*, 1*b*, 2?)

Calymene latifrons, Bronn, 1825: Leonhard's Zeitschr. f. d. Mineral., p. 317, t. ii, figs. 1–8.

Phacops latifrons, Sandberger, 1850: Verstein. Rheinisch. Schichtensyst. Nassau, t. i, fig. 7.

Phacops latifrons, Salter, 1864: Mon. Pal. Soc., pt. i, p. 18, pl. i, figs. 9–16.

I have referred Nos. 1, 2, 6, and 9 of Mr. Howard Fox's specimens to *Phacops latifrons*, Bronn, which is one of the most characteristic forms of Devonian Trilobites, and is recorded by writers on this formation from Cornwall, Devon, the Eifel, in Germany, and elsewhere.

No. 1 is a rolled up and very much compressed specimen drawn on Pl. V, Fig. 1*a*, in profile; the same specimen being also shown from the underside in Fig. 1*b*. Fig. 1*a* exhibits the right cheek or glabella, and the large compound eye, which is very prominent in this species. The surface of the glabella (which in *P. latifrons* is covered with coarse tubercles) is completely obliterated in this specimen by the compression which the fossil has undergone in the matrix. The angle of the cheek is bluntly rounded off and not produced into a genal spine, the border is rounded and slightly elevated. The visual surface of the eye forms a raised crescent, 9 mm. above the cheek border, with a length of 18 mm. along its outer curved surface. It shows upwards of twelve rows of facets, each row having from five to six distinct prominent rounded lenses upon its surface. The compressed body and head are 35 mm. in thickness and 50 mm. long in profile in their present folded up state.

Fig. 1*b* shows the flattened out thoracico-abdominal segments and a part of the pygidium seen from below. The most anterior segments are seen in the profile view, where they unite with the head-shield (Fig. 1*a*); the others in Fig. 1*b*. About ten or eleven free segments can be counted altogether. The ends of the pleuræ are recurved and rounded. A part of the pygidium is exposed, but the rest is buried in the matrix. There is a trace of a single row of three or four tubercles upon the axis of some of the free thoracic segments. The body-segments are 58 mm. broad by 51 mm. long.

No. 2 specimen (see Pl. V, Fig. 2) consists of a pygidium accompanied by five or six displaced thoracic segments. The pygidium is much flattened. It measures 52 mm. in breadth by 36 mm. in length. The axis is composed of about ten or eleven coalesced segments, and is 14 mm. broad at the proximal end (where it united with the free body segments), diminishing to 6 mm. near the blunted free border, which is quite flattened out by pressure. Indications of about six coalesced pleuræ mark the lateral portion of the pygidium; the axis and pleuræ are sparsely ornamented by a single row of small tubercles on each segment. The general rounded form of the pygidium is marred by the extreme compression to which it has been subjected.

On No. 6 (marked doubtfully as *Ph. latifrons*?) are two badly-preserved specimens of Trilobites, each showing the head and body rings on the edges of the cleavage-planes (which are stronger than those of the original bedding); both specimens are stained red with peroxide of iron. Except in general resemblance, they are too obscure for accurate determination. Locality as before stated, Cant Hill, St. Minver.

No. 9 exhibits parts of several obscure organisms, preserved on the surface of a small slab, some of which appear to be crinoidal, but one is the eye of a Trilobite, and may be referred to *Ph. latifrons*. This species is recorded from the Lower Devonian, Hope and Barton, South Devon; near Liskeard and Totnes in slates with *Pleurodictyum problematicum*. Middle Devonian, Newton Bushell; Upper Devonian, Barnstaple, Pilton, Yealm Bridge, Launceston. Mr. Howard Fox's specimens are labelled from Cant Hill, St. Minver, on the northern banks of the Camel Estuary.

2. Phacops granulatus, Münster. (Plate V, Figs. 3, 4.)

Calymene granulata, Münster, 1842: Beiträge, Heft 5, t. v, fig. 3.
Calymene granulata, Phillips, 1841: Pal. Foss., fig. 248 (excl. figs. *m*, *n*, *o*, *p*).
Phacops granulatus, Salter, 1864: Mon. Pal. Soc., pt. i, p. 18, pl. i, figs. 1–4.

This species is recorded by Salter from the Upper Devonian of Petherwin, Cornwall. Although so small (Pl. V, Fig. 3) it is the best preserved and most interesting of Mr. Fox's specimens. It consists of an intaglio and relievo of a small Trilobite (represented twice the natural size in our Plate), measuring 24 mm. long by 12 mm. broad (originally broader, but compressed by slaty cleavage), and resting on the edges of the cleavage planes and

parallel with them, which accounts for its having escaped even greater distortion.

McCoy originally described it in 1851 in his "Synopsis of Woodwardian Fossils," p. 177. Salter defines it as "General form broad-oval. Head semicircular, very convex, covered with granules. [Owing to the absence of the tests the ornaments of tubercles on the glabella cannot be seen in Mr. Fox's specimen, but traces of these can be detected in the intaglio.] The sides (cheeks) much bent downwards. Glabella fully half the width of the head, very tumid, slightly pointed in front, and overhanging the front margin. Its greatest width exceeds its length, even including the neck-segments; a small basal lobe, with a tubercle on each side, but no glabellal furrows visible. Cheeks moderate [genal border rounded posteriorly], with a strong border. Eyes large, prominent, with few, about thirty-six, lenses, five in a row" (after McCoy). We may add to this:—Thorax consisting of eleven well-defined free-segments; axis strongly arched, semi-cylindrical, with a deep furrow separating it from the pleuræ; pleuræ strongly recurved, rounded, and somewhat expanded at their extremities. Pygidium semicircular, small, convex, surface somewhat smooth, axis well marked, but divisions of pleuræ only faintly indicated.

Measurements: length of head 7 mm., of eye 4 mm., of thorax 12 mm., of pygidium 5 mm.; breadth of axis of body 3 mm. Mr. Howard Fox's original specimen is from east of Cant Cove, St. Minver.

No. 4. This specimen (Pl. V, Fig. 4) no doubt belongs also to the same species as No. 3. It gives a side view of another example, in which, however, the head is partially wanting, but the crushed glabella and the left eye can be detected.

Total length 24 mm. Head 6 mm. long; length of (11) thoracic segments 12 mm.; pygidium 6 mm. Breadth of exposed axis and left pleuræ 8 mm. (broadened by pressure). The form of the pleuræ with their rounded, recurved, and expanded extremities is well seen in Fig. 4. This specimen also comes from the Devonian of Cant Hill, St. Minver.

No. 5. This example is not figured. It is similar in condition to No. 4, but is *less* well preserved. All the thoracic segments seem present; the head, however, is wanting (or represented only by the projecting eye); the pygidium is also absent. Length 15 mm. Same locality as preceding specimen.

3. Phacops (Cryphæus) punctatus, Steininger. (Pl. V, Fig. 5.)

Olenus punctatus, Steininger, 1833: Mém. Soc. Géol. Fr., vol. i, p. 356, pl. xxii.
Phacops punctatus, Salter, 1864: Mon. Pal. Soc., p. 59, pl. i, figs. 17–19 (and woodcut, p. 59).

This specimen is marked No. 7 in Mr. Howard Fox's collection, and like the others is from Cant Hill, St. Minver. It consists of the profile of a head of a trilobite showing the free-cheek and compound facetted eye. The margin of the free-cheek has a strong ridge along it, and, although so imperfect a fragment, I am inclined

to refer it to *Phacops punctatus*, Steininger. The surface of the shield is punctate, the head margin is produced in front of the glabella; the posterior angle of the free-cheek, though not complete, shows that it was originally prolonged backwards into a genal spine. Length of fragment 15 mm., length of visual surface of eye 5 mm.

Mr. Salter, in 1864, records imperfect specimens of this species as having been found in the Middle and Lower Devonian of Torquay, South Devon, and from the slates of Liskeard, Cornwall, and he remarks: "It is certain that a very beautiful Trilobite has yet to be found in Cornwall and S. Devon, and collectors should look carefully for it" (Pal. Soc. Mon., p. 60). We have now to add the locality of St. Minver.

No. 8 consists of an imperfect series of nine thoracic segments, and a trace of head and pygidium from Cant Hill. The free extremities of the pleuræ are less curved and less expanded than in *Ph. latifrons* or in *Ph. granulatus*, and the pygidium appears to be more narrow and elongated, but this may be due to distortion in the rock. I do not propose to determine this specimen specifically, but it may be a distorted fragment of *Phacops* (*Trimerocephalus*) *lævis*, which has been obtained both in North and South Devon and at Mudstone Bay, etc.

EXPLANATION OF FIGURES OF TRILOBITES ON PLATE V.

Fig. 1*a*.—Profile of *Phacops latifrons*, Bronn. Devonian: Cant Hill, St. Minver, Cornwall. × $\frac{1}{3}$.
,, 1*b*.—Under side of same specimen. Nat. size.
,, 2.—*Ph. latifrons* (?). Pygidium. Devonian: Cant Hill, St. Minver, Cornwall. Nat. size.
,, 3.—*Ph. granulatus*, Münster. Profile of a nearly perfect specimen from same formation, east of Cant Cove, St. Minver. × 2.
,, 4.—*Ph. granulatus*, Münster. A less perfect specimen, showing thoracic segments, imperfect head and pygidium. Same formation, Cant Hill, St. Minver. × 2.
,, 5.—*Ph. punctatus*, Steininger. An imperfect cheek, with eye. × 2.

(For explanation of Figs. 6–8, Pl. V, see end of Mr. G. C. Crick's paper.)

III.—On some Fossil Cephalopoda from North Cornwall collected by Mr. Howard Fox, F.G.S.

By G. C. Crick, F.G.S., of the British Museum (Natural History).

(PLATE V, Figs. 6–8.)

THE following descriptions are based upon fossils sent to me for determination by Mr. Howard Fox, F.G.S. Excepting the specimen which is compared with *Orthoceras hercynicum* and is marked "E. of Cant Cove," the fossils are from Cant Hill, St. Minver, N. Cornwall.

At the end of the descriptions are added notes upon some very imperfect fossils which Mr. Fox has collected from other localities in St. Minver.

ORTHOCERAS cf. HERCYNICUM, E. Kayser. (Pl. V, Figs. 6*a*, 6*b*.)

Orthoceras hercynicum, E. Kayser: Abhandl. zur geolog. Specialkarte v. Preussen, etc., Bd. ii, Hett 4 (1878), p. 72, pl. x, figs. 7, 8, 11; pl. xi, fig. 3 (?).

Among the specimens submitted to me by Mr. Howard Fox there are several examples of the genus *Orthoceras*. The most nearly perfect specimen is represented in Pl. V, Figs. 6*a*, 6*b*. It is a crushed internal cast about 200 mm. in length, of which the body-chamber occupies about 55 mm. The rate of tapering is about 1 in 5, the greatest width at the aperture being about 40 mm., and at the last septum about 28 mm. In its crushed condition the depth of the chambers is about one-third of their width. The siphuncle is slightly excentric (see Fig. 6*b*). Parallel to, and at about 8 mm. below the aperture on the side of the body-chamber opposite to that which is figured, there is a shallow constriction about 6 mm. wide. There are no remains of the test: the surface of the cast is smooth. The specimen, though evidently much compressed during fossilization, probably originally had an elliptical cross-section. The septa are rather oblique, but being nearly parallel to the aperture this obliquity may be due in great measure to crushing. On the whole the specimen seems to be comparable with such a form as *Orthoceras hercynicum*, described by Kayser from the limestone at Hasselfelde in the Hartz belonging to the lower part of the Middle Devonian, or with the form which Kayser figures and describes as *Orthoceras* sp. (op. cit., p. 72, pl. xi, fig. 1), from the same horizon and locality.

A septated fragment, about 45 mm. long, is possibly referable to this same species.

ORTHOCERAS cf. COMMUTATUM, C. G. Giebel.

(See Text-figures, p. 156, Figs. 1, 1*a*.)

Orthoceras commutatum, C. G. Giebel: Fauna der Vorwelt, Bd. iii (1852), p. 233.[1]

Another *Orthoceras* indicating a different species is represented in the accompanying figures (Figs. 1, 1*a*). It is flattened, slowly tapering, and about 92 mm. long; the ventro-dorsal and transverse diameters in its present crushed state being 25 and 51, and 23 and 40 mm. respectively. It consists of the internal casts of three chambers, and of part of a fourth, the anterior one being imperfect; the septa are about 21 mm. apart. The siphuncle is not clearly shown, but at the posterior end of the specimen there appears to be a faint indication in a slightly excentric position of something which may have been the siphuncle. There is also a depression at the anterior end, but this seems to be the impression of another organism. The surface of the cast is smooth; there are no traces of any sculpture. This specimen, characterized by its deep chambers and slowly tapering shell, appears to be related to the Devonian form which Kayser has figured (loc. cit., pl. x, figs. 1–3; pl. xi, figs. 4, 8) as *Orthoceras commutatum*, Giebel, and recorded from the limestone at

[1] This is the species which was described as *Orthoceras longicameratum* by Foord (Cat. Foss. Ceph. Brit. Mus., pt. i, 1888, p. 80), but this name being preoccupied Foord altered it to *O. nassoviense* (ibid., Corrigenda and Addenda, p. xxxi). The species, however, is evidently the same as that for which Giebel had already proposed the name *O. commutatum*.

Hasselfelde in the Hartz, a locality which also yields the previously-mentioned species, *Orthoceras hercynicum*.

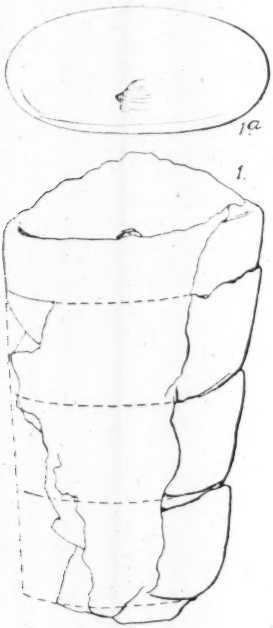


Fig. 1.—*Orthoceras* cf. *commutatum*, C. G. Giebel, showing internal casts of three chambers, and of part of a fourth. 1*a*, anterior end of the same specimen. Cant Hill, St. Minver, Cornwall. Drawn of two-thirds of the natural size. (The reduction of the figure causes the chambers to appear shallower than they really are.)

Cophinoceras sp. (Pl. V, Figs. 8*a*, 8*b*.)

The fossil which is here referred to this genus consists of a natural internal cast of a (probably the greater) part of the body-chamber and of the six preceding chambers of a slightly curved shell. It measures on the outer or convex curve about 140 mm., of which the body-chamber occupies about 82 mm. Only one side and a small portion of the other are exposed. The specimen is much flattened, its greatest thickness being only about 28 mm. The greatest width of the fossil is at about the middle of the portion of its septate part, and is about 78 mm., but the boundary of the concave surface of the specimen is not exposed. Of the chambers that are preserved the oldest is the deepest, being at the middle of the lateral area 12·5 mm. deep; in a similar position the two next are each about 10 mm., the next about 8 mm., the two last being each about 6 mm. deep. Near the anterior end of the specimen there is a very broad, ill-defined, shallow constriction, so that the anterior boundary of the fossil, at least the right-hand side of it, probably represents the

border of the aperture. The latter does not appear to have been constricted as in the genus *Phragmoceras*, but widely open. The fossil appears to bear slight traces of the ornaments of the test. These are most conspicuous on the body-chamber, and consist of several faint parallel longitudinal ridges from 5 to 12 mm. on the outer, convex, or ventral surface; they extend on to the septate part of the shell, where, however, most of them are much less distinct owing to the roughness of the surface of the specimen, but the innermost ridge, which is at about 30 mm. from the outer boundary of the specimen, is very pronounced and somewhat irregular, as though the test here might have been roughly nodose. On the body-chamber these ridges are connected by transverse, fairly closely-set, but slightly irregular lines crossing the interspaces between the ridges in curves which are forwardly-concave. There are also some rather coarser and more irregular wavy lines near the base of the inner or dorsal portion of the body-chamber, but these may not be traces of any surface ornaments. On the inner or dorsal side of the body-chamber a strongly incised line starts from the last septum at about 12 mm. from the inner edge of the fossil; passing forwards and curving over towards the dorsal side, it reaches the boundary of the fossil at a point about 12·5 mm. in advance of the last septum. Judging from observations in other fossils the writer believes this to indicate the boundary of one of the shell-muscles, this being, in fact, the impression of one of the muscle-scars as it was preserved on the inside of the test, the latter having subsequently disappeared. When received the dorsal portion of the specimen was entirely obscured by matrix, and the fossil looked very much like a portion of a *Phragmoceras*, but the removal of the matrix from the dorsal surface revealed the incised line just referred to, and this suggests to the writer that the fossil is referable to a widely-apertured shell rather than to a form with a contracted aperture such as *Phragmoceras*.

In general appearance the fossil presents some resemblance to the specimen figured by D'Archiac & De Verneuil as *Phragmoceratites subventricosus*[1] from the Middle Devonian of the Eifel, but that species seems to lack the characteristic sculpture of the present specimen.

The fossil appears to be referable to Hyatt's genus *Cophinoceras*,[2] a genus confined to the Middle Devonian, and including both cyrtoceracones or slightly curved forms and gyroceracones or loosely coiled forms. The genotype is *Cyrtoceratites ornatus*, D'Archiac & De Verneuil (Trans. Geol. Soc., ser. II, vol. vi, pt. 2, 1842, p. 349, pl. xxvii, fig. 5), originally described from the

[1] Trans. Geol. Soc. London, ser. II, vol. vi, pt. 2 (1842), p. 351, pl. xxx, figs. 1, 1*a*. Referred to *Cyrtoceras* (*Ooceras*) *flexuosum*, Schlotheim, sp., by A. H. Foord: Cat. Foss. Ceph. Brit. Mus., pt. i (1888), p. 316.

[2] Proc. Boston Soc. Nat. Hist., vol. xxii (1883), p. 285. See also E. Holzapfel: Abhandl. d. k. Preuss. geolog. Landesanst., Neue Folge, Heft 16 (1895), pp. 123 et seq. Hyatt originally spelt the name *Kophinoceras*, a spelling adopted by Holzapfel; but in Eastman's translation of Zittel's Textbook of Palæontology (1900) Hyatt spells the name *Cophinoceras* (p. 522).

Middle Devonian of the Eifel, but occurring also in the Devonian of Mudstone Bay, South Devon,[1] and to this species the present specimen appears to be allied. Other examples of this genus were figured by Phillips in his work on the Palæozoic fossils of Cornwall, Devon, and West Somerset, and by Whidborne in his Monograph on the Devonian Fauna of the South of England, but the fossil under consideration cannot be definitely referred to any of these, nor indeed to any of the forms described by Holzapfel in his work entitled "Das obere Mitteldevon (Schichten mit *Stringocephalus Burtini* und *Maeneceras terebratum*) im Rheinischen Gebirge."[2] The specimen appears to have been originally somewhat laterally compressed, but it has doubtless suffered considerable additional compression during fossilization. We have not ventured to name this fossil, the affinities of which, however, indicate that it is of Middle Devonian age.

PHRAGMOCERAS (?) sp. (Pl. V, Fig. 7.)

The specimen doubtfully referred to this genus is the small natural internal cast figured in Pl. V, Fig. 7. It is the posterior portion of the septate part of a rapidly expanding shell. It is 15 mm. long, its anterior and posterior diameters being 12 and 6·5 mm. respectively, five[3] chambers being obscurely visible. It is slightly curved, and seems therefore to have been the posterior portion of a *Phragmoceras* rather than of a *Gomphoceras* or *Poterioceras*, but it is too imperfect for accurate determination.

AGONIATITES sp. (Text-figures 2, 2*a*.)

The genus *Agoniatites* is represented by a laterally compressed and very much distorted example (see accompanying figures). The specimen consists of the natural internal cast of the greater part of the body-chamber, and of the two preceding chambers, but is so much crushed that its original dimensions cannot be ascertained. It was evidently a rather rapidly expanding shell. The greatest height at the anterior part of the body-chamber is 42 mm. At the base of the body-chamber (see Fig. 2*a*) the height of the whorl from the margin of the umbilicus to the small median lobe of the suture-line is 27 mm., the greatest width of this part of the shell being 16·5 mm. The periphery appears not to have been acute, but a little flattened, there being indications of such a flattening near the base of the body-chamber, the flattened portion being apparently about 2·5 mm. wide. The curve on the inner edge of the body-chamber (see Fig. 2) shows that the fossil was not very widely umbilicated. Although crushed and considerably distorted, the form of the septal surface shows clearly that the specimen is

[1] Described and figured as *Cyrtoceras* (?) *bdellaites* by J. Phillips, Pal. Foss. Cornwall, Devon, and West Somerset, 1841, p. 117, pl. xlvii, figs. 223*a*, *b*, and referred to D'Archiac & De Verneuil's species by A. H. Foord, Cat. Foss. Cephl. Brit. Mus., pt. ii (1891), p. 58.

[2] Abhandl. d. k. Preuss. geolog. Landesanst., Neue Folge, Heft 16 (1895).

[3] Six chambers are indicated in the figure.

referable to the genus *Agoniatites*.[1] No signs of sculpture are observable on the side of the body-chamber that is figured, but on the opposite side on the outer portion of the lateral area there are faint regularly-spaced striæ, which are coincident in direction with the septa on the side, but are strongly projected forwards nearer the periphery. This genus is highly characteristic of, if not strictly confined to, the Middle Devonian.

Phillips[2] figured and described from South Devon examples of this genus under the names *Goniatites inconstans* (p. 123, pl. li, fig. 238) and *Goniatites transitorius* (p. 140, pl. lx, fig. 227*), whilst Whidborne[3] described and figured in addition to these two other forms *Goniatites obliquus* (p. 56, pl. v, figs. 1–3) and *Goniatites fulguralis* (p. 59, pl. v, figs. 4, 4*a*), which are also referable to this genus,[4] but the present specimen does not appear to

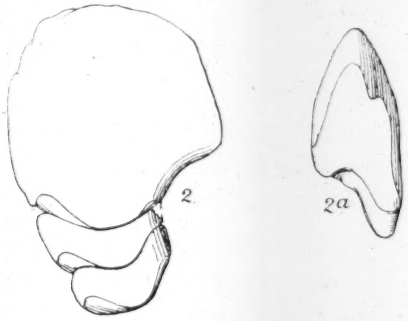


FIG. 2.—*Agoniatites* sp., lateral aspect of internal cast of body-chamber and of two preceding chambers. 2*a*, posterior view of base of body-chamber of the same specimen, showing form of septal surface, the small median lobe being crushed a little to the right side of the specimen. Cant Hill, St. Minver, N. Cornwall. Drawn of two-thirds of the natural size.

be referable to any of these forms. It seems to be comparable rather with such forms as Barrande's *Goniatites bohemicus*[5] and *G. tabuloides*,[6] being, however, more inflated than the latter and possibly not so coarsely ornamented as the former. Both of Barrande's forms come from his Étage G, that is, from the Eifelian or lower portion of the Middle Devonian. Whilst, therefore, the

[1] F. B. Meek: U.S. Geol. Explor. 40th Parallel, vol. iv (1877), pt. 1, p. 99.

[2] J. Phillips: "Figures and Descriptions of the Palæozoic Fossils of Cornwall, Devon, and West Somerset" (Mem. Geol. Surv.), 1841.

[3] "Monograph of the Devonian Fauna of the South of England" (Pal. Soc.), pt. ii (1890).

[4] Holzapfel (Abhandl. d. k. Preuss. geol. Landesanst., Neue Folge, Heft 16, 1895, p. 55 et seqq.) unites all these forms into one species—with several varieties—for which he retains Phillips's name *inconstans*, a species which he states to be confined to the Upper Middle Devonian.

[5] J. Barrande: Syst. Sil. de la Bohême, vol. ii, pt. 1 (1867), p. 29, pl. i, figs. 1–13; pl. ii, figs. 1, 2; pl. iii, figs. 15, 16; pl. ccxlii, fig. 1; pl. ccxliv, figs. 3, 4.

[6] Ibid., p. 41, pl. iv, figs. 1–12.

present specimen cannot be specifically determined its affinities seem to indicate that it came from rocks of Lower Middle Devonian age.

Notwithstanding the fragmentary character of the specimens described above, their affinities seem to show that they are all certainly of Devonian and most probably of Eifelian or Lower Middle Devonian age.

In addition to the specimens described above, Mr. Howard Fox has submitted to me for examination some very imperfect fossils from other localities in North Cornwall.

Of the two specimens which are marked "E. of Dinham Creek," one seems to be referable to the fairly common species in the Wissenbach Slates that was described as *Orthoceras longicameratum* by Foord[1] (= *Orthoceras commutatum*, C. G. Giebel[2]). The other, nearly 70 mm. long, is a rather rapidly tapering *Orthoceras*, intermediate in this respect between Roemer's *Orthoceras rapæforme*[3] and his *O. subconicum*,[4] but having shallower chambers than either of these species. Both Roemer's species occur in the Wissenbach Slates.

Among some specimens labelled "Trewornan" are probably *Orthoceras nassoviense*, Foord (= *O. commutatum*, C. G. Giebel). *O. gracile*, Blumenbach,[5] and a fragment of a *Bactrites*. These species of *Orthoceras* are rather common in the Wissenbach Slates, from which two or three species of *Bactrites* have also been recorded.

There are two rock fragments labelled "Gravel Caverns." Of these one contains an obliquely-septated fragment of possibly a *Bactrites*, or more probably an *Orthoceras*, a little more than 10 mm. long; the other a small water-worn Goniatite 2·5 mm. in diameter, with very indistinct suture-lines, belonging to the genus *Tornoceras*.

EXPLANATION OF PLATE V, FIGS. 6–8.

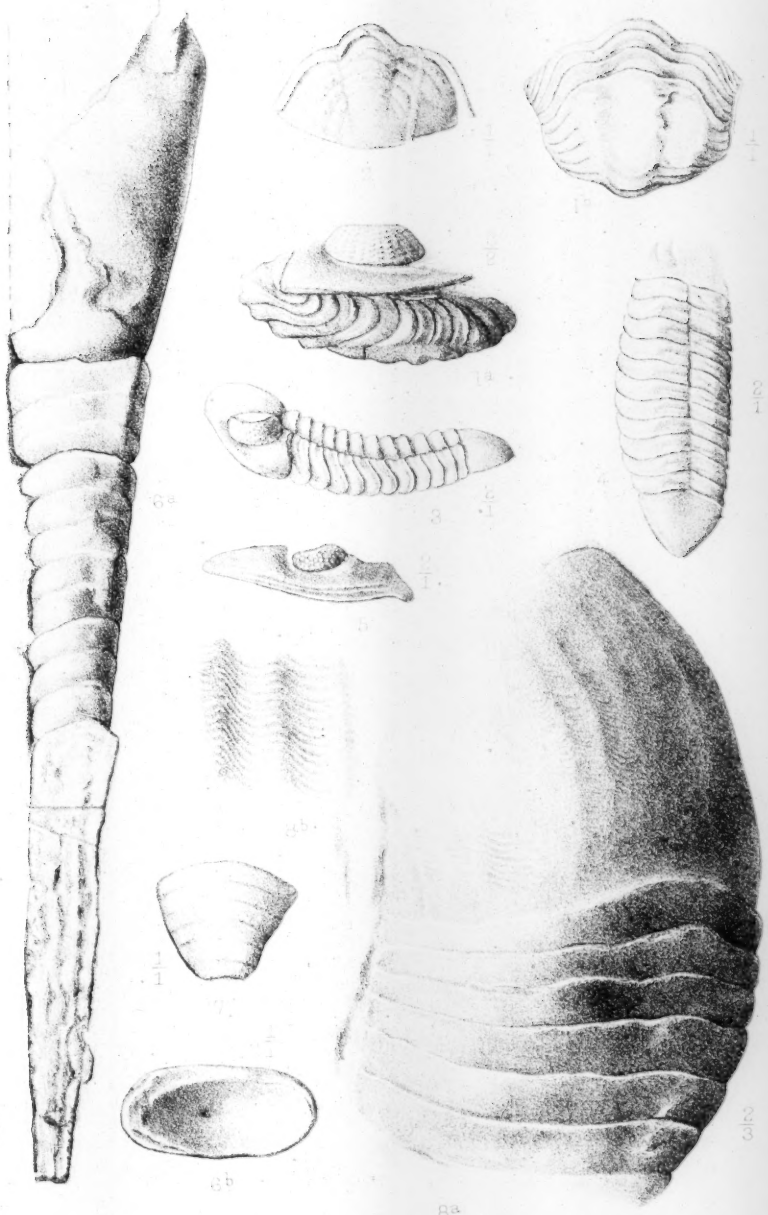
FIG. 6.—*Orthoceras* cf. *hercynicum*, E. Kayser. *a*, entire specimen reduced to two-thirds of the natural size; *b*, anterior aspect of last septal surface, showing the position of the siphuncle, drawn of the natural size. E. of Cant Cove.

,, 7.—*Phragmoceras* (?) sp. Nat. size. Cant Hill, St. Minver, Cornwall.

,, 8.—*Cophinoceras* sp. *a*, lateral aspect of entire specimen, reduced to two-thirds of the natural size; *b*, a portion of the markings on the body-chamber enlarged. Cant Hill, St. Minver, Cornwall.

(For Figs. 1–5 of this Plate, see Dr. H. Woodward's "Notes on Trilobites from Cornwall," pp 151–154.)

[1] See *antea*, p. 155, footnote.
[2] C. G. Giebel: Fauna der Vorwelt, Bd. iii (1852), p. 233.
[3] F. A. Roemer: Palæontographica, Bd. iii, Lief. 1 (1850), p. 16, pl. iii, fig. 18.
[4] F. A. Roemer: ibid., p. 17, pl. iii, fig. 20.
[5] Blumenbach: Specimen Archæologiæ Telluris, 1803, p. 21, pl. ii, fig. 6.



G.M. Woodward, del. et lith.

West, Newman, imp.

Devonian Cephalopods and Trilobites from Cornwall.

IV. — *Sympterura Minveri*, n. g. et sp.: a Devonian Ophiurid from Cornwall.

By F. A. Bather, M.A., D.Sc., British Museum (Natural History).

(PLATE VI.)

Description of the Holotype.

THE specimen (Fig. 6), kindly entrusted to me for description by Mr. Howard Fox, consists of the oral skeleton surrounded by portions of the disc and of portions of the five rays, all seen from what is believed to be the ventral or actinal surface, and lying on a fragment of the dark slate of the locality, Epphaven. The skeletal parts being preserved in pyrites, it has proved possible to develop the specimen slightly by washing with weak hydrofluoric acid and then brushing with a soft brush. The specimen is, however, so minute and delicate that this process could not be carried very far.

The rays vary in length and, to some extent, in the details shown by each. It is therefore convenient to number them in a solar direction from i to v, i being the longest and v the next in length. These numbers are not to be taken as implying any certain orientation.

Ray i, from its junction with the mouth-parts to the distal portion preserved, is divisible into nine serially homologous segments, of which the ninth or distal-most is incomplete laterally. There is no evidence as to the complete number of segments that originally composed the ray. Those preserved change slightly in character as they approach and enter the disc, which included one of them certainly and a second possibly; but all show the same elements, except for the lateral spines, which are not borne by the segments within the disc. The lateral spines are borne by the free segments 3–8 in groups of three, each group being at the distal outer angle of each segment. The spines of each group diverge fanwise, but the general outward direction of the middle spine of each triad is slightly distal-wards. It is the clear position of these groups of spines which, more than any other feature, enables one to divide this ray into its nine definite segments. Each segment, however, seems capable of subdivision into a proximal and a distal portion (*b* and *a* in Figs. 1 and 2). There is a median body from which proceed two lateral processes or wings on each side. The distal wing has an approximately straight distal margin, lying about at right angles to the axis of the ray, while its proximal margin is deeply excavate. This excavation is clearer in the more distal segments (Fig. 1, *p*), and its boundary there attains a full semicircle. The proximal wing of each segment forms the proximal boundary of this excavation, and, in the more distal segments, its distal margin is slightly excavate. In the proximal segments (Fig. 2) this wing appears more like a flattened rod, slightly depressed on its proximal margin, while the distal wing is also like a flattened rod somewhat scooped out on its ventral surface.

The relations of the wings are perhaps most clearly shown in the eighth segment; here the outer corners of the distal wings seem to overlie processes from the median body (*c* in Fig. 1). The transverse separation of the median body of one segment from that of the next is not very clear. In the distal part of the ray there are indications of a separation not only between the segments, but between the two halves of each segment. The median bodies are slightly grooved on the ventral surface, so that a continuous open groove runs the whole length of the preserved portion of the ray, and passes into the radial angles of the oral skeleton.

Ray v is in a different state of preservation, having apparently been somewhat twisted over on to the side that lies on the right in the figure, so that the ventral groove, which in its proximal region is median, is seen on the right in the distal region. In the preserved portion of the ray the existence of four distinct segments is pretty clearly indicated by transverse ridges and indentations, also by two spines, one at the distal end of the third segment, the other at the end of the fourth, both on the left-hand in the figure. Apparently there are here preserved only the median bodies, a fact which might suggest that they were distinct elements from the side-wings. There are, however, traces of the wings on the left of the second and third segments. In none of these segments is there a clear indication of a subsidiary transverse division.

The other rays are too incomplete to throw any light on the structure of the segments, but in their proximal segments the side-wings are to be distinguished, especially in ray iv.

The oral skeleton (Fig. 3) is divisible into five radial portions, each of which is bilaterally symmetrical about the radius, and at first sight appears to consist of two curved bars or syngnaths enclosing a lanceolate space, of which the apex is distal, while the proximal ends of the bars approach closely those of the adjacent bars on each side. More minute examination shows that each of the supposed curved bars consists of three elements, to which may be applied the terminology adopted by Dr. J. W. Gregory, the distal element being a 'mouth-frame,' the proximal one a 'tooth,' and the intermediate one a 'jaw.' Of these three elements the jaws are the longest, and broaden at their distal ends; the distinction between them and the mouth-frames is marked either by a sharp bend or an actual gap. The mouth-frame is about two-thirds the length of the jaw; each pair is joined distally to the median body of the proximal ray-segment. The teeth also are distinguished from the jaw by a sharp bend at the point of union, while they lie a little above the jaw as one views the specimen from the ventral surface. There is no sign of a 'jaw-plate' or 'torus angularis'; there may have been a small one, or the structures here called 'teeth' may represent primitive unfused elements of the torus, such as have been observed in the development of recent Ophiurids. Fewkes states that in *Amphiura* the teeth grow out from the torus and have no independent centres of calcification.

The disc is best preserved in the interradius v–i. It certainly extended up the rays to the distal end of the first segment (*d* in Fig. 2), and perhaps a little further, but whether its outline was straight or concave interradially cannot be decided. It was clothed with minute spines radiating from the centre.

The following are some measurements of the specimen in millimetres :—

Greatest length of the portion preserved	11·5
Diameter of disc	*circâ* 6·5
From centre to distal end of mouth-skeleton	*circâ* 2·0
Width of ray	1·5
Length of lateral spines, at least	1·8
Average length of a segment	·76

Interpretation of the Holotype.

Owing to the difficulties of interpretation, the foregoing description of the rays has been drawn up in as objective a fashion as possible. Some interpretation, however, is a necessary preliminary to any discussion of the relationships of the fossil.

The median body of each segment is undoubtedly the equivalent of the normal Ophiurid vertebra. On the accepted theory that this vertebra was evolved by the fusion of a pair of ossicles originally alternating, then opposite, and finally joined along the middle or radial line, the present specimen may be described as in a stage of development later than the fusion, but possibly retaining in the median groove a trace of the primitive distinctness of the ossicles. Those ossicles are usually described as ambulacral, and that term may be accepted so far as it denotes homology with the ossicles so named in an Asterid. (See Note at end.)

It was the existence of the median groove that first suggested the determination of the exposed surface of the fossil as ventral. But since such a groove may occur also on the dorsal surface of a vertebra, that evidence is inconclusive. The determination is confirmed, however, by the conspicuousness of the subcircular excavations, or podial pores, in the side-processes, and by the apparent continuation of this groove over the radial angles of the mouth-frames.

As a rule among Ophiurids in this stage of evolution, each vertebra has on each side a single side-process on which abuts an outer ossicle, the so-called adambulacral, and these adambulacrals, which bear the lateral spines, alternate with the ambulacral ossicles or vertebræ. It is a little difficult to interpret the appearances of the present specimen in harmony with such an arrangement. On the assumption that each segment should contain one ambulacral pair (here fused) and one adambulacral pair bearing spines, ray i has been assigned nine segments. But each such segment is seen to have two processes on each side, and the distal one of these bears the spines. For this reason, and because of the appearances in segment 8, it may be supposed that the outer spiniferous portion of the distal process (*c* in Fig. 1) is an adambulacral element. What, then, is the proximal side-process? To this question two possible answers present themselves.

The appearance of a transverse division in the vertebra, between the proximal and distal processes, suggests that each segment really consists of two ambulacral pairs, of which only the distal one is associated with adambulacrals, the proximal pair of adambulacrals being suppressed. Each of these supposed ambulacral pairs possesses a single pair of lateral processes, but those of the distal pair are partly overlaid by the adambulacral elements. In the distal region of the ray the proximal and distal halves of the vertebra are distinguishable; but nearer the disc and within it they have come closer together, the transverse division has disappeared, and the side-processes are reduced to structures which appear as bars, but are probably flattened laminæ. Thus the vertebræ seen in ray v are, on this explanation, of compound origin.

The preceding interpretation may be compared with Dr. Gregory's interpretation of the structure in the Lower Devonian Ophiurid, *Bundenbachia*[1] (see our Fig. 5). Here "the body of the [ambulacral] ossicle is apparently divided into two pieces by a transverse depression. The adambulacral plates are small and narrow, and support a triangular spine-bearing plate." If, however, as seems legitimate, this last plate be regarded as itself an adambulacral element, then each segment will consist of two ambulacral pairs, and two adambulacral pairs of which one only is spiniferous. The fact that in *Bundenbachia* the ambulacrals still alternate does not affect the composition of the segment. *Bundenbachia* is not to be regarded as a direct ancestor of the contemporary Epphaven fossil, but it suggests the possibility that, during the race-history of the Ophiurids, there may have arisen forms with a tendency to suppression of alternate adambulacrals and to fusion of adjoining ambulacrals.

In *Bundenbachia* there appear to be preserved both adambulacral and ambulacral elements of the subsequently suppressed or coalesced segment. The Silurian *Protaster Sedgwicki* appears to retain the ambulacral elements less reduced than in *Bundenbachia*, while it has lost the adambulacral elements. In the proximal arm-segments, however, as figured by Dr. Gregory (op. cit., fig. 1*c*), the existing adambulacrals are forked, a peculiarity suggestive of their compound origin.

Now comparison of the vertebræ of recent Ophiurids with the arm-segments, especially the proximal ones, of our fossil leaves no room for doubt that the depression marked *p* is for the reception of a podium, while that marked *q* is for the insertion of the ventral inter-vertebral muscles. A single arm-segment of a recent Ophiurid, such as *Ophiarachna* or *Amphiura*, is therefore homologous with any one of the whole segments here numbered 1–8. If one of these is really composed of a distal and a proximal half (lettered *a* and *b* respectively in Figs. 1 and 2) the same statement would apply to the recent Ophiurid, and some trace of this origin might be seen in the development. The observations of Professor Ludwig[2] and

[1] Proc. Zool. Soc. London, 1896, p. 1033; 1897.
[2] Zeitschr. wiss. Zool., vol. xxxvi, p. 181; 1881.

Mr. J. W. Fewkes[1] on *Amphiura squamata* have shown that the two lateral halves of each vertebra unite first at the proximal and distal ends, leaving a space between. This is suggestive of an origin from proximal and distal elements. On the other hand, each lateral half springs from a single centre of calcification, from which it stretches out in a distal direction, so that the incipient ambulacral element is thicker at its proximal end. This last-mentioned feature is paralleled by the boot-shaped proximal portions of the ambulacral ossicles in the Protasteridæ. At a slightly later stage the ambulacral of *Amphiura* broadens at the distal end, which thus comes to resemble the distal portion of the Protasterid ambulacral. If this distal portion in *Amphiura* were, as indicated by Professor Ludwig's observations, merely an extension of the proximal portion, then it might be inferred that the whole structure, both here and in the various Palæozoic forms alluded to, represented a single ambulacral pair and not two successive pairs. In such case one would accept Dr. Gregory's suggested explanation (op. cit., p. 1032) "that the smaller pieces are only triangular, distal portions of the ambulacral ossicles, apparently separated from the proximal portion[s] by a groove." Dr. Gregory further suggests that these grooves or depressions "were for the lodgment of the ventral muscles which moved the arms." A far more probable explanation surely is that they were for the reception of the branches from the radial water-vessel to the podia. This explanation, however, consonant as it is with the facts of development in *Amphiura*, reminds one of another difficulty. Professor Ludwig (op. cit., p. 185) has pointed out that, whereas the so-called ambulacrals of Asterids lie at right angles to the perradius and between the successive branches and podia, those of Ophiurids lie parallel to the perradius and across the branches to the podia. Now if, as we have every reason to believe, the Ophiurids were derived from Asterids, it is hard to see why this change should have taken place. That is the difficulty, but it is a difficulty that disappears if we suppose that the vertebra is really compounded of two successive ambulacral pairs in the manner outlined above. The remaining objection to this latter hypothesis is that, as Dr. Gregory has pointed out, it postulates the suppression of alternate podia. Nevertheless, similar fusion and concomitant suppression are not so unknown among Echinoderms as to render this objection a fatal one.

The suggestion that the vertebræ of Ophiurids are composed of two successive ambulacral pairs certainly cannot be proved with the evidence at our disposal. But it is doubtful whether it can be disproved, and I therefore make it to promote a search for further evidence *pro* or *con*.

Two other features in the present specimen need discussion, and may perhaps throw light on the problem just posed. The first of these is the fact that the broadest and stoutest portion of each arm-segment appears to be the distal half (marked *a* in Fig. 1), whereas in the developing *Amphiura* and in the adult Protasteridæ

[1] Bull. Mus. Comp. Zool. Harvard, vol. xiii, No. 4; 1887.

the reverse is the case. This character is also found in *Furcaster palæozoicus* as figured by Mr. Stürtz, in *Ptilonaster princeps* of J. Hall, and in *Lapworthura Miltoni* as interpreted by Dr. Gregory (see our Fig. 4). In the Epphaven fossil the feature is to some extent accounted for by the supposed fusion of a spiniferous adambulacral element with the distal wing of the ambulacral; but in *Lapworthura* and *Furcaster* this wing, while unconnected with the adambulacral, is still more preponderant. In some other early Palæozoic genera, e.g. *Eugaster*, J. Hall, and *Eophiura*, Jaekel, the wing is neither distal nor proximal, but arises half-way up the ambulacral, so that one cannot say to which of two successive segments the podium belongs: in fact, the structure is in this respect absolutely that of an Asterid.[1] These differences call for some explanation. Starting from the indifferent Ordovician type of *Eophiura*, we may suppose that in one series of genera (e.g. Protasteridæ) the wing moved towards the mouth, while in another series (e.g. Lapworthuridæ) it moved away from the mouth. In both series the podium ultimately became enclosed within the substance of (apparently) a single ossicle; but, if this took place by a subsequent lateral outgrowth of stereom, then in the former case the vertebra must have enclosed a podium distal to itself, and in the latter case a podium proximal to itself. Thus the relations of the vertebræ to the podia would be fundamentally different in the two lines of descent. On the other hand, alternate podia may, as suggested on a previous page, have been enclosed by the union of successive pairs of vertebræ, and this type of structure may be the one seen in process of development in the arm-segments of our fossil, and the one that persisted to the present day.

The second feature worthy of attention is the considerable space that seems to intervene between the distal wing of one segment and the proximal wing of the next. This is conspicuous in the distal region of ray i, where, further, the depression (*q* in Fig. 1) markedly resembles the podial depression (*p* in Fig. 1), and differs from it mainly in being rather nearer the axis of the arm. The theory that the Ophiurids are descended from Asterids does not explain the evolution of such an interspace, and the general tendency to shortening and approximation of the vertebræ, shown in the history of the Ophiurids, leads one to enquire why there should ever have been introduced a stage in which, as in the Devonian *Ophiurina*, the recent deep-sea *Ophiohelus*, and the young *Amphiura*, the vertebræ have so far departed from the primitive type as to become axially elongate. This stage has been regarded as primitive by Lyman, Ludwig, and other zoologists, but in theory and fact it is 'primitive' only so far as the later forms are concerned, while with reference to the complete series it is 'intercalated.'

Recurring to the hypothesis that the vertebræ are compounded of successive pairs of ambulacrals, we find in it an explanation not

[1] See Dr. O. Jaekel's interesting account of genera from the Lower Palæozoic rocks of Bohemia, intermediate between Asterids and Ophiurids: Zeitschr. Deutsch. geol. Ges., lv, Protok. pp. 106–113; 1904. References to the older literature will be found in Dr. Gregory's oft-quoted paper.

merely of this curious elongation of the arm-segments in general, but of the interspaces between them in this genus (lettered *q*). An objection to the hypothesis was the necessity for assuming the suppression of alternate podia. Here, it may be, is evidence of a stage in which those podia were not yet suppressed, though perhaps somewhat atrophied. If both depressions (*p* and *q*) were for the reception of podia, then their alternate approximation to and removal from the perradius may be compared with the similar phenomenon in Asterids.

Whether the features just discussed be or be not accepted as evidence in favour of the compound origin of the Ophiurid vertebra, they demand some explanation; and it may be added that the same hypothesis will perhaps furnish an equally needed explanation for the hitherto unexplained differences that obtain between Palæozoic genera of Ophiurids in the relations of the adambulacrals to the ambulacrals.

The origin of the Ophiurid mouth-skeleton also may be illuminated by the preceding hypothesis, which is in full harmony with the opinion that many more arm-segments enter into the composition of that structure than is the case in Asterids, an opinion based on embryological research by Dr. O. zur Strassen,[1] and on palæontological investigation by Dr. O. Jaekel in the paper quoted above. In this region of the ray, at any rate, adambulacrals and podia must have been suppressed in all Ophiurids. We may here note the apparent absence from our specimen of the adambulacral elements known as side mouth-shields, as well as of the peristomial plates. The latter are wanting in most early Ophiurids, a fact confirmatory of Dr. zur Strassen's conclusion that they are not ambulacral elements, but "secondary calcifications confined to the interradial region."

Systematic Position.

In considering the systematic position of this fossil we have two systems to choose from: one, that proposed by Dr. Gregory in the paper above quoted, and adopted by him in "A Treatise on Zoology" (ed. Lankester, London, 1900); the other, the latest classification by Mr. B. Stürtz (Verh. nat. Ver. preuss. Rheinlande, lvi, p. 198, 1900). The two classifications have much in common, and, without discussing their respective merits, it will be convenient to start with Dr. Gregory's as more accessible to English readers.

The union of the ambulacrals into vertebræ removes the fossil from the Order Lysophiuræ and from the Streptophiuran Family Ophiurinidæ, while the absence of a covering integument or scutes prevents it being placed in any of the other Orders or in any Family of Streptophiuræ other than Lapworthuridæ or Eoluididæ. Of these two Families the former has no ventral arm-plates, and the latter, while having ventral ones, has no dorsal arm-plates, except in *Aganaster*. If the exposed surface of this fossil be rightly regarded as ventral, the specimen must belong to the former Family. The genera herein contained are *Lapworthura*, Greg., *Furcaster*, Stürtz,

[1] Zool. Anzeiger, xxiv, p. 609; Nov. 1901.

and *Palastropecten*, Stürtz (syn. *Palæospondylus*, Stürtz). The last of these differs from the Epphaven fossil in almost every respect, but the two others present a slight general resemblance in arm-structure. In each, for instance, the vertebral body has distal wings, and in *Lapworthura* these wings surround large subcircular pores; but in both the adambulacrals have a different position, while there is no proximal wing, although the diagram of *Lapworthura* given by Dr. Gregory and here repeated (Pl. VI, Fig. 4) shows a minute incipient process. In the known species of these genera also the disc extends further down the rays, which are relatively wider, while the proportions of the various elements of the mouth-skeleton are different.

The Family Eoluididæ includes *Eoluidia*, Stürtz (syn. *Eophiurites*, Stürtz), *Eospondylus*, Greg., *Miospondylus*, Greg., *Aganaster*, Miller & Gurley (syn. *Ophiopege*, G. Böhm), and perhaps *Cholaster*, Worthen & Miller. The last two have both ventral and dorsal arm-scutes, while as for the others they differ in much the same respects as do *Furcaster* and *Lapworthura*, only to a greater extent and with no superficial resemblance.

It seems therefore safest to place this fossil in the Lapworthuridæ, with the diagnosis of which it agrees so far as the structure is known. If the subdivision of Gregory's Family into Lapworthuridæ, Furcasteridæ, and Palæospondylidæ (i.e. Palastropectinidæ), as proposed by Stürtz, should be accepted, our fossil would still be most appropriately placed in Lapworthuridæ. It is, however, quite impossible to refer it to *Lapworthura* itself, and a new genus must be established for its reception. From a geological point of view it would have been more interesting could one have referred it to some known species, or at least genus, found in the Devonian of Germany. But repeated comparison with the rich material in the British Museum has proved this course inadmissible, whatever errors there may be in the details of the present interpretation.

SYMPTERURA,[1] nov. gen.

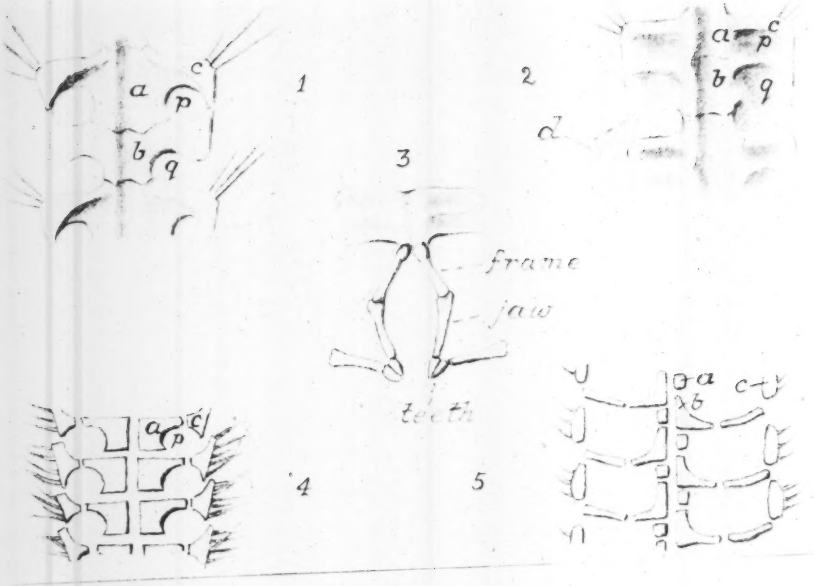
A Lapworthurid with spinulose disc extending to second arm-segment, with oral skeleton of teeth, long jaws, and short mouth-frames (torus not seen), with free arm-segments containing a vertebral ossicle, possibly compound, grooved ventrally and provided on each side with two wings, to the distal of which is attached an adambulacral spiniferous element.

Genotype. *Sympterura Minveri*, n.sp.

This being the only known species, a diagnosis is impossible, but attention may be directed to the relative narrowness of the rays, the extension of the disc, and the length and number of the spines.

Holotype, a unique specimen collected by Miss Barbara Legg in the blue slate of Epphaven, which is a cove between Lundy Beach and Trevan Point in Portquin Bay, in the parish of St. Minver, near Padstow, North Cornwall. When Mr. Howard Fox was so good as to send me the specimen for examination, I acknowledged

[1] σύν and πτερόν, 'paired wings,' and οὐρά, 'tail,' as in *Ophiura*, *Lapworthura*, etc.



ii

iii

i

iv

6 x 7

v

its receipt in a rather informal letter, extracts from which have since been published by him (Trans. R. Geol. Soc. Cornwall, xii, p. 752, Sept. 1904). One sentence ran: "So far as I can judge without more prolonged study [the fossil] is either *Ophiurina* or a close ally." The structure had not then been developed by etching and brushing. It is now quite clear that the specimen has nothing to do with *Ophiurina*, which is in the Lysophiuran stage, with long rod-like unfused ambulacrals. Mr. Fox has since kindly presented the specimen to the British Museum, where it is registered E 5,036.

Horizon.—The rock is certainly Devonian, but on its precise age the present specimen, being of a new generic type, can throw little light. The stage of evolution at which *Sympterura* stands, namely, primitive Streptophiuran, is fully consistent with a Lower Devonian age.

Note.—In this paper I have used the term 'ambulacrals' for the elements of which the Ophiurid vertebra is composed, and in so doing have followed the general custom. But many writers, from Johannes Müller onwards, have contended that the so-called ambulacrals of Asterids and Ophiurids are not homologous with those plates in Echinoidea for which the term was originally proposed. This contention has much in its favour. At any rate, the so-called ambulacrals of Asterids are homologous with the flooring plates of the subvective groove in Edrioasteroidea, and not with the covering plates, which latter are usually called ambulacrals, as in Pelmatozoa generally.

For practical purposes also, I have used the ordinal names Streptophiuræ and Lysophiuræ, proposed by Mr. F. J. Bell and Dr. J. W. Gregory respectively. But it seems to me that the divisions adopted by my friends and colleagues represent stages of development rather than divergent groupings, and while admitting the great interest and value of the conceptions, I cannot follow Dr. Gregory in ranking them as Orders.

EXPLANATION OF PLATE VI.

Fig. 1.—*Sympterura*, semi-diagrammatic reconstruction of the 8th arm-segment and part of the 7th. *a*, distal portion of the vertebra; *b*, proximal portion; *c*, adambulacral; *p*, podial depression or pore; *q*, interspace, occupied, at least in part, by intervertebral muscles. × 18 diam.

,, 2.—*Sympterura*, semi-diagrammatic reconstruction of the 2nd arm-segment and part of the 1st. *a*, *b*, *c*, *p*, *q*, as in Fig. 1; *d*, border of disc. × 18 diam.

,, 3.—*Sympterura*, semi-diagrammatic reconstruction of part of the mouth-skeleton. × 10 diam.

,, 4.—*Lapworthura*, diagram of the arm-structure, after Gregory, Proc. Zool. Soc. London, 1896, p. 1037. *a*, *c*, *p*, as in Figs. 1 and 2.

,, 5.—*Bundenbachia*, diagram of the arm-structure, after Gregory, op. cit., p. 1034. *a*, *c*, *b*, as in Figs. 1 and 2. Dr. Gregory is not responsible for the lettering in Figs. 4 and 5.

,, 6.—*Sympterura Miueri*, the unique specimen. The numbering of the rays is for convenience only. In drawing this figure I was helped by preliminary sketches made by Mr. W. Lewis before the specimen was fully cleaned. × 7 diam.

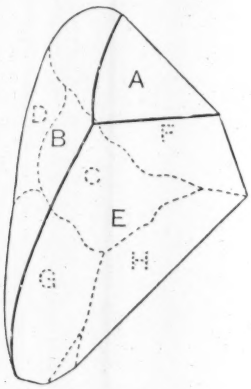
All figures represent views of the ventral surface. The drawings are reproduced by the London Stereoscopic Company, Limited.

V.—A Description of the Big Diamond recently found in the Premier Mine, Transvaal.

By F. H. Hatch, Ph.D., F.G.S., and G. S. Corstorphine, Ph.D., F.G.S.

(PLATES VII AND VIII.)

GREAT interest has been excited, not only in the Transvaal, but throughout the world, by the discovery at the Premier Mine, on Wednesday, the 25th January, 1905, of the largest diamond hitherto known. The stone was found by Mr. Wells, Surface Manager, in the yellow ground about 18 feet from the surface, a brilliant flash of light from a projecting corner having caught his attention. After a preliminary cleaning it weighs $3{,}024\frac{3}{4}$ carats. According to Gardner Williams the South African carat is equivalent to 3·174 grains; consequently the diamond weighs 9600·5 grains troy or 1·37 lbs. avoirdupois. Through the courtesy of the Directors of the Company, we have been enabled to make an examination of the stone, with the following result:—Roughly speaking, it measures 4 by $2\frac{1}{2}$ by 2 inches; but its size and shape will be best realized by



Diagrammatic Projection (to half scale).

reference to the photographs reproduced on Plates VII and VIII, which represent the diamond from four different points of view and its actual size. These beautiful photographs were taken by Mr. E. H. V. Melvill for the purposes of this description. The stone is bounded by eight surfaces, four of which are faces of the original crystal, and will be referred to in this description under the letters A, B, C, D, and four are cleavage surfaces, the cleavage being of course parallel to the face of the octahedron. In the following description these cleavage surfaces are referred to under the letters E, F, G, H. They are distinguished from the original octahedral faces by greater regularity and smoothness. The shape and relative position of these various surfaces can be seen in the diagrammatic

projection depicted in the Text-figure, which has been drawn in the Mineralogical Laboratory of the Oxford University Museum, by the kind permission of Prof. Miers, F.R.S. The drawing is to half scale.

Description of the Surfaces.

A is an original octahedral face showing typical striations, the bands varying from 0·1 to 0·4 centimetre, and running parallel to the edge A–E.

B is a large surface slightly curved showing partial striations, which, however, are interrupted by the slightly mammillary character of the surface.

C is also a natural surface showing a few striations parallel to the edge C–E.

D. Between B and F, C, G, there is an irregular octahedral face D, showing distinct equilateral triangular indentations which resemble etched figures, except in regard to their comparatively large size, the largest having a side measuring 0·7 centimetre. D is parallel to E.

E, F, G, H, are cleavage planes.

E is the largest of these, and is a very perfect cleavage plane. Parallel to it within the crystal there is a small air layer between two internal cleavages, producing a 'rainbow' or Newton's rings.

F is the second largest of the cleavage planes and shows a small spot within the crystal.

G is an irregularly shaped cleavage plane.

H is another cleavage face showing series of cleavages in the corner bounded by E and G. Two spots are visible, one actually on the surface, the other about 1 cm. within the crystal.

Of the faces given, A and G, H and B, and E and D are parallel. In the case of B and H the parallelism is imperfect owing to the curvature of B.

The purity of the crystal is best seen on looking into face E, and the lustre is well seen on the irregular natural face B, the broken cleavage on H causing a good deal of refraction which affects B to some extent as the facets of a cut gem would. For a large stone the crystal is of remarkable purity, and the colour approximates to that of a blue-white.

The large size of the cleavage planes E and F indicates that a very considerable portion of the crystal is wanting. From the shape of B, D, and G, one can say that the entire crystal was irregular in shape, but A and D being octahedral faces, the presumption is that the complete crystal was a distorted octahedron, probably with dodecahedral faces developed on the edges. The portions missing probably amount to more than half of the original crystal.

The Cullinan diamond, as it has been named, after the Chairman of the Premier Company, is more than three times the weight of the largest diamond previously known—the famous stone found in 1893 at Jagersfontein in the Orange River Colony, which weighed 972 carats.

EXPLANATION OF PLATES.

PLATE VII.

FIG. 1 shows the original face A at the top of the stone. In front is the cleavage plane E, which, however, is not clearly visible owing to the light reflected from the somewhat irregular surfaces at the back of the crystal. On the extreme right is the cleavage plane H.

FIG. 2 shows the cleavage plane F, which, on account of its favourable position relative to the camera, appears as a brilliantly illuminated surface; the irregular original faces C and D also appear in this view.

PLATE VIII.

FIG. 3 shows the triangular indentations on the irregular face D; also portions of A and B.

FIG. 4 shows the crystal resting on the cleavage plane E with the faces B and D exposed to view. The sharp bounding edges are formed as follows: at the bottom by E, on the right by A, and on the left by G.

VI.—THE CLASSIFICATION OF THE PHACOPIDÆ.

By F. R. COWPER REED, M.A., F.C.S., of the Sedgwick Museum, Cambridge.

THE family of Trilobites termed Phacopidæ has been defined by Beecher[1] as follows:—"Glabella tumid, widest in front. Free cheeks continuous, united anteriorly. Suture extending from in front of the genal angles inward to the eyes, and thence forward around the glabella. Eyes generally large, always with distinct facets, schizochroal. Thorax of eleven segments with grooved pleura. Pygidium usually large and of many segments; limb ribbed; margin entire or dentate."

Nomenclature in use.

While the general limits and characteristics of the family as thus given are universally recognised, much confusion and diversity of opinion still exist as to the generic groups which must be therein included. There is no precise agreement in the usage of many of the common generic names; and many subgenera have been from time to time established without general acceptance. Some palæontologists (e.g. Salter) have been of the opinion that the family only contained one genus, *Phacops*, which might be split up into several subgenera. Barrande, however, recognised the presence of two genera, *Phacops* (in a more restricted sense than Salter) and *Dalmania* or *Dalmanites*; and Hall & Clarke in 1888[2] adopted this view. Beecher in 1900 (op. cit.) mentioned six divisions or groups within the limits of the family, and put them all as of equal generic value.

Other examples of differences in the classification of the family need not here be given; but in order to show the multitude of generic or subgeneric groups which have been established, but of which only a few have been generally adopted, the following list

[1] Beecher, Amer. Journ. Sci., vol. iii (1897), p. 202; and in Zittel's "Textbook of Palæontology" (English translation, 1900), p. 636.

[2] Hall & Clarke: Palæont. New York, vol. vii, pp. xxvii–xxxii.

Fig. 1.

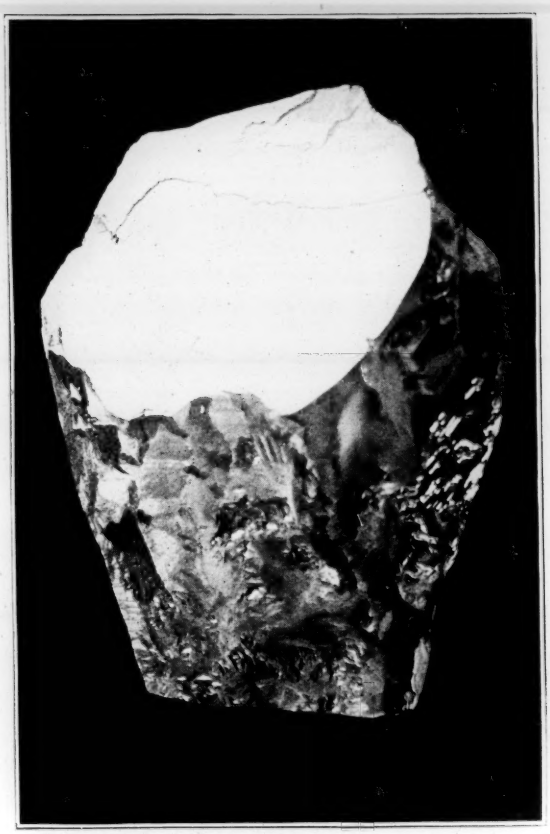


Fig. 2.

THE "CULLINAN" DIAMOND.
Actual size.

Fig. 3.

From Photographs by E. H. V. Melvill.

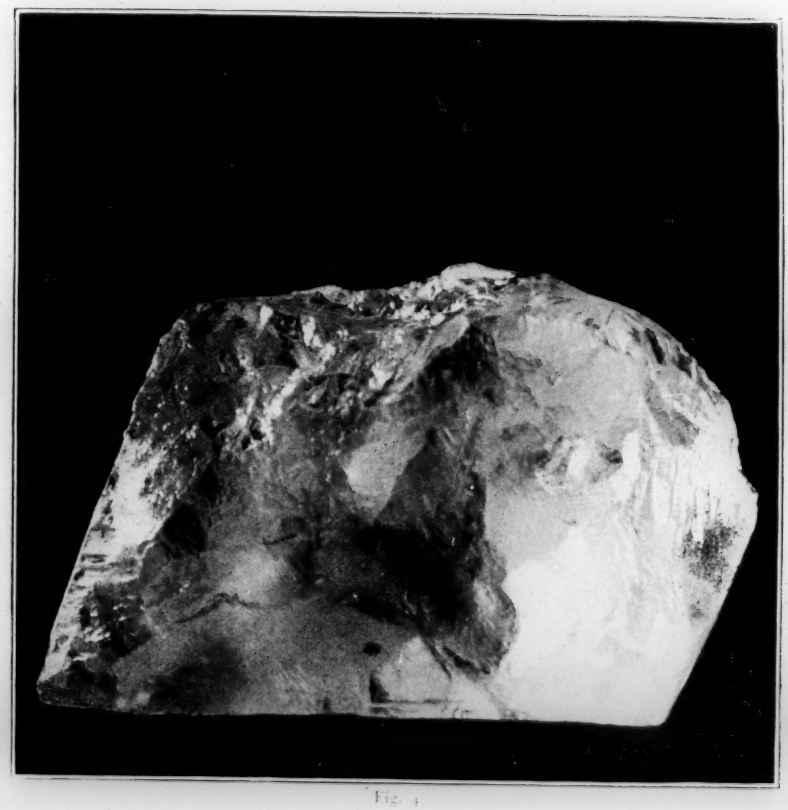


Fig. 4.

THE "CULLINAN" DIAMOND.
Actual size.

may be given, irrespective of questions of synonymy or pre-occupation, which will be dealt with subsequently :—

Acaste, Goldfuss, 1843.
Asteropyge, Corda, 1847.
Chasmops, McCoy, 1849.
Coronura, Hall & Clarke, 1888.
Coryecephalus, Hall & Clarke, 1888.
Cryphæus, Green, 1837.
Cryphina, Oehlert, 1889.
Dalmania, Emmrich, 1844.
Dalmanites, Barrande, 1852.
Hausmannia, Hall & Clarke, 1888.
Homalops, Remelé, 1884.
Malladaia, Oehlert, 1896.
Metacanthus, Corda, 1847.
Monorakos, Schmidt, 1886.
Odontocephalus, Conrad, 1840.
Odontochile, Corda, 1847.
Phacops, Emmrich, 1839.
Pleuracanthus, Milne-Edwards, 1840.
Portlockia, McCoy, 1846.
Probolium, Oehlert, 1889.
Pterygometopus, Schmidt, 1881.
Somatrikelon, McMurtrie, 1849.
Symphoria, Clarke, 1894.
Trimerocephalus, McCoy, 1849.

Of the above names, *Pleuracanthus* and *Cryphæus* are both pre-occupied, the former both by a genus of Coleoptera (Gray, 1832) and by a genus of fishes (Agassiz, 1837), the latter by a genus of Coleoptera (Klug, 1833). *Cryphæus* was founded on the American species *Cr. Boothi*, Green, of which *Cr. collitelus*, Green, which possesses a median terminal spine to the pygidium as well as the five lateral pairs, was considered merely a variety by Hall.[1] Corda, in dealing with the similar European species *C. arachnoides* (Hoeninghaus) and *C. stellifer*, Burmeister, considered the presence or absence of the terminal spine a feature of generic importance; and accordingly put them in separate genera, which he called *Asteropyge* and *Metacanthus* respectively. Salter[2] was the first to denounce the artificiality and weakness of this division; so that, as *Cryphæus* is not available as a generic or group name, *Asteropyge* must be used as its designation. Kayser[3] has endeavoured to subdivide *Cryphæus* again into Corda's two sections.

Though the type-species of *Dalmania* is *D. caudatus* (Brünn.) and that of *Odontochile O. Hausmanni* (Brong.), (or as Barrande declares *D. Reussi*, Barr.), yet it was early recognised that these species were congeneric. Both *Dalmania* and *Odontochile* were unfortunately preoccupied, the former by a genus of Diptera (Robineau Desvoidy, 1830) and the latter by a genus of Coleoptera (*Odontocheila*, Laporte, 1834), so that Barrande proposed the name *Dalmanites*, which though often used in a very wide sense, yet must hold good as the group-name of which the type-species is *D. caudatus*. Hall & Clarke[4] employed the name *Dalmanites* in such a wide sense that they proposed the name *Hausmannia* for the sub-group containing the type-species; but Oehlert[5] considers it an unnecessary duplicate name.

Acaste must be considered as preoccupied, the name *Acasta* having been given by Leach in 1811 to a genus of Cirripedes. There is no strict synonym for this group, so that the name must be

[1] Hall & Clarke: op. cit., p. 45.
[2] Salter: Mem. Geol. Surv., dec. ii, 1849, art. 1, p. 8.
[3] Kayser: "Die Fauna ält. Dev. Ablag. Harzes," p. 33 (Abhandl. geol. spec. Kart. Preuss., Bd. ii, Heft 4, 1878).
[4] Hall & Clarke: op. cit., p. xxxi.
[5] Oehlert: Bull. Soc. Géol. France, sér. III, vol. xvii (1889), p. 758.

replaced by a new one if the morphological or phylogenetic claims of the group which it marks are sufficient to warrant a distinctive title.

The divisional names, therefore, which remain after this preliminary weeding-out are the following :—

'Acaste.'	*Monorakos.*
Asteropyge.	*Odontocephalus.*
Chasmops.	*Phacops.*
Coronura.	*Portlockia.*
Coryecephalus.	*Probolium.*
Cryphina.	*Pterygometopus.*
Dalmanites.	*Somatrikelon.*
Homalops.	*Symphoria.*
Malladaia.	*Trimerocephalus.*

Whether all the above divisions have sufficient morphological or phylogenetic value to be retained in a natural system of classification is the question now to be discussed.

Principles of Classification.

Dismissing from our minds all ideas and prejudices derived from customary usage and past authorities, it is worth while considering in what manner we should group the members and species of the Phacopidæ supposing we were to start completely *de novo*. The principles for a natural arrangement are acknowledged to be found in the modifications of the head-shield, as we have learned especially from Professor Beecher's valuable researches. In the case of the members of a compact family such as the Phacopidæ the changes in the glabella offer the best guide, and these changes are shown by the fusion or reduction or even disappearance of certain lobes. The modifications in the thorax, which always retains the fixed number of eleven segments, are of secondary morphological value and of minor developmental importance; and while there is an immense amount of variation in the characters of the pygidium in shape, number of segments, and ornamentation, yet the evidence of the trilobites as a whole and of individual families (e.g. the Cheiruridæ) indicates that structural changes in this part of the body occur in less regular succession and pursue often an independent or eccentric development, so that for the purposes of a classification which is intended to be based on phylogeny they are of less significance than those in the head-shield.

Starting, then, from the well-established view of the primitive pentamerous composition of the head-shield of trilobites, we may expect to find this pentameric segmentation best exhibited in the earliest and least modified members of the family. The phylogeny may be anticipated to follow the ontogeny which has been traced in more than one species of *Phacops*.

The group termed *Dalmanites* by Barrande, using the name in its widest and most comprehensive sense, most clearly preserves the fivefold division of the head-shield. In the early post-embryonic stages of its species, as well as at maturity, the five segments are well displayed. The retention of this primitive character throughout

the whole history of the group must be undoubtedly interpreted as of considerable importance, though even in the larval stages some tachygenetic features appear which stamp the group as belonging to one of the higher and later families of trilobites. There does not seem to be any reason for considering the pentamerism of the later and more specialised forms of *Dalmanites* as signs of retrogression or as senile re-adoptions of pre-adult and early characters; for the succession of *Dalmanites*-forms is traceable in practically a continuous and unbroken series from their first appearance to their extinction.

The loss of the original pentamerism of the head-shield to a greater or less extent, as illustrated by a large number of members of the family, must be taken as a departure from primitive conditions and as a sign of specialisation and an advance in development.

This structural change may take place in either of two ways, (1) by the fusion of two or more of the successive lobes; or (2) by the unequal growth of the lobes, leading to the reduction in size or squeezing-out of some of them. In the first case the obsolescence or complete disappearance of the segmental (lateral) furrows concerned accompanies the change; and in the second case the lobes themselves are more or less lost.

It is noticeable that these types of structure in the head-shield do not absolutely replace each other in regular chronological succession, but frequently exist contemporaneously; the more highly specialised type did not drive out the simpler type, and the old primitive stock from which the others must have been derived held its ground in spite of the vigorous growth of its lateral offshoots, even lasting till the final disappearance of the family.

A large number of intermediate conditions between the perfect pentamerous and the lobeless or paucilobed forms of Phacopidæ have been observed, and this has given rise to the abundant and varied nomenclature. Many of the so-called genera, subgenera, and groups or sections have been founded on these transitional forms, which are of much interest from a developmental point of view, but these distinctive names of higher than specific rank have obscured the broad features of the phylogeny, particularly in cases where the occurrence of such forms is purely local and their representation restricted to a single species.

The presence of so many intermediate links has rendered the division of the family into sharply separated and well-defined genera a matter of extraordinary difficulty, as the literature on the subject illustrates, hardly two authorities agreeing completely on the limits of the various divisions of the family.

Lines of Development.

Regarded as a whole we may distinguish three lines along which the development of the Phacopidæ has proceeded, and they start from an early stage in the history of the family. Two of these lines find their culmination in the Devonian period, where they are represented by the typical *Phacops* with a lobeless or

nearly lobeless short glabella, and the specialised types of *Dalmanites* with an elongated well-segmented glabella. Hoernes[1] had traced the whole history of these two parallel branches of the family in Bohemia from the Ordovician to the Devonian, and has clearly shown that the typical *Phacops* is derived by a series of progressive changes from the primitive forms of *Dalmanites* which form the root of the whole family.

Along the *Dalmanites*-line a pentamerous segmentation of the head-shield with a more or less elongated cranidium and glabella have persisted, though the glabella has been occasionally modified by the unequal or irregular growth of the lobes, and even by the partial obliteration of some of the lateral furrows; the head-shield also has in some cases accompanied these changes by the production of various marginal or superficial ornaments or processes, but their development in other cases has been independent.

Along the other line there has taken place a general shortening of the cranidium, with a loss of segmentation occasioned by the obsolescence or disappearance of the lateral furrows of the glabella; the lobes have become more or less completely fused, the glabella inflated, and the outline of the head-shield generally rounded without any marginal processes.

Concurrent changes in the thorax and pygidium are also noticeable along each line.

In the *Dalmanites*-branch the thorax tends to become flattened, and to develop free-pointed ends to the pleuræ, while the number of the segments in the pygidium increases, and its extremity becomes mucronate, or the margin may be produced into various spinose processes. The general tendency to develop spines and processes on the head-shield and pygidium is a marked characteristic of the later members of this branch.

On the other hand, the *Phacops*-branch tends to have all points rounded off; the genal angles of the head-shield are usually rounded and not produced; there is an absence of spinose ornaments on the head; the thorax becomes more convex; the pleuræ have their ends obtuse or rounded; the pygidium is not elongated, but assumes a semicircular more or less transverse form without terminal or lateral processes, and consists of comparatively few segments. Hoernes traces the origin of this *Phacops*-branch from the primitive *Dalmanites*-forms (e.g., *D. socialis*, *D. Phillipsi*, etc.), and upwards through the Silurian group of *Phacops Glockeri* and its allies.

As we should expect from our knowledge of the ontogeny, the earliest members of the whole family have a pentamerously segmented head-shield. This is the case in Bohemia, as Hoernes notes, and also in England, where the earliest Phacopids are *Ph. Nicholsoni* of the Skiddaw Slates and *Ph. llanvirnensis* of the Upper Arenig (Llanvirn Beds).

The primitive *Dalmanites*-group may be therefore regarded as constituting the stock from which later groups have branched off,

[1] Hoernes, Jahrb. Geol. Reichsanst. Wien, Bd. xxx, Heft 4 (1880), pp. 651–686; and id., Kosmos, Jahrg. iv, Bd. viii (1880), pp. 20–32.

and its characters are, as we should anticipate, somewhat composite and varied. The elements of future lines of development are found to be contained within its limits. For example, the genal angles are sometimes spined and sometimes rounded; the same is the case with the extremities of the thoracic pleuræ; the pygidium, though always consisting of fewer segments than in the *Dalmanites* of later periods, is in some species elongated and mucronate, while in others it is rounded and has a simple margin. Two sub-groups can in fact be distinguished in the Bohemian group of primitive *Dalmanites*, as Hoernes has pointed out: one sub-group marked by *D. Angelini* and *D. socialis*, leading onward into the typical Silurian *Dalmanites*, while the other, which comprises such forms as *D. atavus* and *D. Phillipsi*, has more in common with the later group of *Ph. Glockeri*.

Branch A.

In the case of the branch culminating in the spinose and otherwise ornamented representatives of *Dalmanites* of the Devonian period, there is no continuous chain of forms in Bohemia connecting the latest developments of the pentamerous series with the early stock. Étage E affords no evidence of the existence of this branch, and perhaps the scene of its evolution was temporarily moved elsewhere. In Northern Europe, and even in the British Isles alone, we are able to fill up this gap to some extent. For in England, succeeding the Arenig forms of early *Dalmanites*, we get a variety of *D. socialis* in the *Orthis argentea* shales of South Wales,[1] and in the Sholeshook and Redhill Beds we find *D. Robertsi*,[2] in which the characters are composite as in the Bohemian early stock. Then comes *D. appendiculatus*, Salter, of the Bala and Ashgill shales, possessing most of the features of a typical Silurian *Dalmanites*, though it has fewer segments in the pygidium. The Silurian formation follows with the type-species of *Dalmanites*, *D. caudatus*, and it is accompanied by numerous allied forms, *D. longicaudatus*, *D. Weaveri*, *D. obtusicaudatus*, etc. During the equivalent period in Bohemia there seems to have been a complete absence of Phacopidæ belonging to the *Dalmanites*-branch. Passing to Scandinavia, we find the Ordovician *D. mucronatus* (which is closely allied to the English *D. appendiculatus*) succeeded by *D. caudatus* and related species. The *Dalmanites*-group is also well represented in North America and in Australia in Silurian beds, and has recently been discovered in Burma. In the following Devonian period we meet with a great and varied development of this group. In most parts of Europe the spinose group of *Asteropyge* occurs, and less commonly the smaller groups named *Malladaia*, *Cryphina*, and *Probolium*. In Bohemia the Devonian representatives of *Dalmanites* resemble structurally the typical Silurian forms of other parts of Europe, except in an increased number of pygidial segments. The other groups seem in this part of Europe to be absent. A notable departure from the

[1] Reed: Geol. Mag., Dec. V, Vol. I (1904), p. 383, Pl. XII, Fig. 2.
[2] Ibid., p. 106, Pl. V.

Silurian type of glabella is found in *Malladaia* by the partial loss or reduction of the third pair of lateral lobes.[1] *Cryphina*[2] differs mainly from *Asteropyge* in the number and shape of the marginal pygidial spines, and *Probolium*[3] is characterised chiefly by the possession of a long frontal rostrum on the head-shield, rudiments of which are found in Silurian species.

(*To be continued.*)

REVIEWS.

JAARBOEK VAN HET MIJNWEZEN IN NEDERLANDSCH OOST-INDIË. Drie en dertigste Jaargang, 1904. Wetenschappelijk Gedeelte: Geologie eines Teiles von West Borneo, nebst einer kritischen Uebersicht des dortigen Erzvorkommens, zusammengestellt von N. WING EASTON, Oberbergingenieur. Zu diesem Werke gehoeren: Ein Atlas und eine Mappe mit Microphotographien. Batavia, Landsdrukkerij.

YEARBOOK OF MINING IN THE DUTCH EAST INDIES. 33rd year, 1904. Scientific Part: Geology of a Part of West Borneo, with a critical review of its Ore Deposits, composed by N. WING EASTON, Chief Mining Engineer. To this work belong an Atlas and a Map with Microphotographs. Royal 8vo: pp. xv, 542, with folio Atlas of 11 coloured geological plates, 1 plate of sections, and 1 of fossils; also 120 microphotographs of Borneo rocks, on 21 plates, with explanatory text. Batavia: State Printing Office.

ABOUT two years since[4] we called the attention of our readers to the elaborate work of Dr. Molengraaff describing his geological explorations in Central Borneo; we have now before us another volume, somewhat more restricted in character, giving an account of the geology of a part of the Residency of West Borneo, which includes the Kapuas district and the territory to the north of it. Mr. Wing Easton, the author of the work, has been about fourteen years engaged, on the part of the Dutch Colonial Government, in mining and geological exploration in this extensive region, and, judging from his descriptions, its topographical and geological features are generally very similar to those of Central Borneo. The country is by no means an ideal one for geological investigation, for there are hardly any well-defined highways, land communication is carried on along narrow footpaths or tracks, often through dense forests, and rock exposures are, as a rule, only met with on the banks of streams. Moreover, the apparently entire absence of fossils in the older sedimentary rocks of Borneo, and their extreme rarity and limited distribution in higher strata, form a serious hindrance to the determination of the real stratigraphical sequence, and, failing

[1] Oehlert: Bull. Soc. Géol. France, sér. III, vol. xxiv (1896), p. 813, woodcut fig. 12.
[2] Id.: op. cit., sér. III, vol. xvii (1889), p. 758.
[3] Ibid., p. 763, pl. xviii, fig. 6.
[4] GEOL. MAG., Dec. IV, Vol. X (1903), p. 167.

these clues, the author falls back on similarity in lithological characters and the degree of disturbance as evidence of correlation.

The oldest sedimentary rocks in West Borneo are dark, hard lustrous clay-slates of considerable thickness, without any admixture of either sandstones or limestones. No fossils have as yet been met with in them. The beds are strongly folded. With the exception of the higher beds of the series, which are supposed to be of Lower Triassic age, these slates are regarded as Palæozoic. They probably correspond to the 'Old Slate Formation' of Molengraaff.

Next above the clay-slates, the rocks consist of micaceous shales and pyritous sandstones, frequently alternating. Associated with the sediments there are massive beds of quartz-porphyry and diabase. In one locality an undoubted Triassic fossil, *Monotis salinaria*, is present, and serves to mark the age of these rocks; also, in siliceous marls and in beds of tuff, Radiolaria occur.

Succeeding the Triassic there comes a series of deposits of shales, marls, sandstones, and occasionally limestones, frequently fossiliferous, belonging to the Jurassic period. The Lias is shown in one locality by the occurrence of *Harpoceras radians*; casts of *Perisphinctes* may indicate Middle or Upper Jura, whilst on higher horizons of the age of the Dogger there are shales and marls containing *Exelissa*, *Corbula*, *Astarte*, and *Protocardium*, in places sufficiently numerous to form a shell-breccia.

Nearly at the base of the Jurassic series, in the neighbourhood of Kendai, there are beds of siliceous shales and marls with a total thickness of about 450 metres, which are rich in Radiolaria, but with the exception of a cast of *Corbula* other fossils were not met with in them. Most of the commoner forms of the Radiolaria described by Hinde in Molengraaff's work were recognized by the author in these deposits, and he is enabled thereby to confirm the opinion expressed by Hinde that they are Jurassic in age. Mr. Wing Easton, however, calls in question the accuracy of Molengraaff's view of the oceanic character of these radiolarian rocks, and considers that they are of brackish-water origin, mainly, it would appear, on the ground that higher in the series they are overlain by thick beds of hard sandstones containing *Corbula* and other shells indicating shallow-water conditions.

Deposits of fine sandstones, tuffs, shales, and marls with Radiolaria, and accompanied by thick beds of diabase and propylite, are referred to the Lower and Middle Cretaceous. Fossils are rare and limited to one locality. Species of the Ammonite genus *Knemoceras* have been determined by Dr. Krause, and are regarded as Cenomanian in age; whilst two Gasteropods, *Itiera scalaris*, Vogel, and *Nerinea* sp., may be of Gault age.

Sedimentary deposits of Tertiary age have not been met with in this part of Borneo, but this period is represented by eruptive rocks, mainly of hornblende-andesite, hypersthene-andesite, and basalt; this last forms extensive surface beds and gigantic flows.

The mineral wealth of Western Borneo has been greatly over-estimated: neither coal nor petroleum has been found; cinnabar,

copper, and lead exist in small quantities; iron, molybdenum, and bismuth are met with, but none of these metals can be worked at a profit. The alluvial gold-bearing deposits are now nearly exhausted; the author considers this gold to have been derived originally from the quartz-porphyry. The alluvial gravels have also yielded diamonds.

With the view of ascertaining if any clue could be found to the relative age of the various sedimentary rocks in Borneo, and for comparison with the eruptive rocks in other parts of the East Indies, the author undertook a thorough investigation of the structure of the various igneous rocks, tuffs, and breccias present in the region, and a detailed description, extending to 160 pages, is given of their microscopical characters. To facilitate comparison, 120 admirably rendered microphotographs representing the principal types of these rocks are given in a separate cover. The author has arranged them under the following groups:—(i) Basalt; (ii) Andesite; (iii) Propylite; (iv) Diabase-diorite; (v) Biotite-diabase with hornblende or olivine; (vi) Uralite and Epidiabase; (vii) Normal Diabase, undoubtedly Triassic; (viii) Diorite, Norite, and Gabbro; (ix) Quartz-porphyry; (x) Granite and Quartz-diorite; and also (xi) Breccias of eruptive rocks.

Further, we may mention the Atlas of 12 carefully-drawn and coloured geological maps and sections and one plate of fossils.

Mr. Wing Easton and his coadjutors merit our congratulations on bringing their arduous labours involved in the preparation of this work to a successful conclusion.

REPORTS AND PROCEEDINGS.

Geological Society of London.

I.—February 17th, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair.

Annual General Meeting.

The Reports of the Council and of the Library and Museum Committee for the year 1904 were read. After premising that the Society continues to be generally in a flourishing condition, the Council stated that there had been a small decrease in the number of Fellows during 1904. The total accession of Fellows in the course of the twelve months under review was 44. During the same period, the losses by death, resignation, and removal amounted to 53. The total number of Fellows on December 31st, 1904, was 1,251.

The balance-sheet for that year showed receipts to the amount of £3,187 3*s.* 9*d.* (including a balance of £192 6*s.* 11*d.* brought forward from the previous year), and an expenditure of £2,777 16*s.* 2*d.*

The completion of vol. lx and the commencement of vol. lxi of the Society's Quarterly Journal was announced.

It was stated that rapid progress was being made with Mr. C. Davies Sherborn's manuscript Card-Catalogue of the Library; and, further, that Mr. Sherborn had undertaken to continue during the current year the preparation of the catalogue-slips for the International Catalogue of Scientific Literature.

In view of the approaching centenary year of the Society (1907) the appointment of a Committee was announced, to carry out the scheme suggested by Mr. H. B. Woodward for the publication of a record which should embody the history of the Society.

The Report of the Library and Museum Committee enumerated the extensive additions made to the Society's Library, and gave some details as to the Card-Catalogue.

The Reports having been received, the President presented the Wollaston Medal to Dr. J. J. Harris Teall, F.R.S., addressing him as follows:—

Dr. Teall,—The Council have unanimously awarded to you the Wollaston Medal, in recognition of the value of your researches concerning the mineral structure of the Earth, and particularly of your contributions to the science of Petrology generally, and more especially to our knowledge of the structure and composition of the rocks of the British Islands.

With regard to the nature of those researches I need add nothing: the published work of a Wollaston Medallist is familiar to the students of our science in all parts of the world, and will remain in evidence to enable the geologists of the future to appreciate its value.

But, although this Medal has been awarded to you for your researches, not on account of these alone are we proud of you.

When presenting to you the degree of Doctor of Science *honoris causâ* in the University of Dublin last year, the Public Orator referred to you as "a man as dear to all for the kindliness of his nature as he is admired by all for the profoundness of his learning." Thanks to this kindliness of nature, you have ever placed your great stores of knowledge at the disposal of other workers. How much work we thus owe to you will never be known, for in helping others you have ever acted on the principle of not letting your left hand know what your right hand doeth; but were it known, I can safely aver that it would be found to have promoted researches concerning the mineral structure of the Earth, to so great an extent as to render you doubly deserving of this Medal.

Each one of your predecessors, in the high post which you occupy as Director of the Geological Survey of the United Kingdom, has received the Wollaston Medal, and we welcome its award to you, who, like them, have done so much to foster the friendly feeling which exists, and will, I trust, ever exist, between the members of that Survey and other geologists.

That it falls to my lot to hand you this Medal is a source of keen pleasure to me. It is now more than a quarter of a century since we first met in our college; and since then I have indeed profited greatly by your ever-ready help, and am pleased to take this opportunity of acknowledging it.

Dr. Teall, in reply, said:—

Mr. President,—To be enrolled on the list of recipients of the Wollaston Medal is, I need hardly say, an honour that I appreciate highly, and the pleasure that I feel is enhanced by the fact that my name will follow very closely upon that of Professor Rosenbusch, to whom I, in common with all other petrographers, owe so much. I am vividly reminded to-day of a personal visit that Professor Rosenbusch paid to me at Kew many years ago, of the kindly interest that he displayed in my early efforts in microscopic petrography, and of the encouragement that he gave me to pursue the study in which I had been initiated by my old friend and College tutor, Professor Bonney. I feel especially indebted to these two former recipients of the Wollaston Medal, and I am glad of this opportunity of expressing my feelings towards them.

I thank the Council of the Geological Society for the very great honour that they have conferred upon me, and you, Sir, for the very kind words with which you have accompanied the award.

The President then handed the Murchison Medal, awarded to Mr. Edward John Dunn, of Melbourne (Victoria), to Professor J. W. Judd, C.B., F.R.S., for transmission to the recipient, and addressed him in the following words :—

Professor Judd,—The Murchison Medal has been awarded to Mr. E. J. Dunn in recognition of his valuable contributions to geological science by the preparation of his geological maps of South Africa and his investigations concerning the occurrence of gold in Australia.

Mr. Dunn's career furnishes the world with an admirable proof, were such needed, of the value of the economic application of our science. Naturally attracted to the science, Mr. Dunn fitted himself for the pursuit of the special branch with which he has been most closely connected, by study at the Royal School of Mines. Although his attention has been chiefly directed to gold-bearing rocks in Africa and Australia, he has not neglected branches of geology unconnected with economics, and has in particular contributed to our knowledge of Glacial deposits in different parts of the world. His labours in mapping portions of South Africa rendered him eminently qualified for the post to which he has now been called—the Directorship of the Geological Survey of Victoria.

Considering the great interest which the founder of this Medal took in the geological conditions which have controlled the distribution of gold, the award of the Murchison Medal to Mr. Dunn is peculiarly appropriate.

In conveying it to him, will you also wish him on our behalf a successful career in his new office, and remind him that the geologists of this island watch with interest and satisfaction the labours of their brethren in Greater Britain.

Professor Judd replied as follows :—

Mr. President,—I regret that the period since the award of this Medal by the Council has not permitted of our receiving a reply to the announcement made to Mr. Dunn at Melbourne. I do not doubt, however, that, on his behalf, I may assure you of the sense which he entertains of the honour that has been conferred upon him by the award of the Murchison Medal. Thirty years have elapsed since Mr. Dunn made his first contributions to this Society, upon the then little-known geology of South Africa; and, during more than thirty years, he has laboured unwearidly in solving geological problems in our Colonies—first in South Africa, and afterwards in Australia. Besides the gratification given to the recipient himself, I feel assured that this award—made by the mother of geological societies to one so closely identified with the progress of our science in the Colonies—will be regarded by them as an act not less graceful than just. It will serve to convince those young and vigorous communities of our sympathy with, and interest in, their efforts to explore the geological features of the vast areas of the Earth's surface which constitute their heritage.

In handing the Lyell Medal, awarded to Dr. Hans Reusch, F.M.G.S., Director of the Geological Survey of Norway, to Sir Archibald Geikie, Sc.D., Sec. R.S., for transmission to the recipient, the President addressed him as follows :—

Sir Archibald Geikie,—The Lyell Medal is awarded to Dr. Hans Reusch, as a mark of honorary distinction and as an expression on the part of the Council that he has deserved well of the science, particularly by his contributions to our knowledge of the geology of Norway.

Born on that "fragment of primeval Europe" extending through Scandinavia and Caledonia, which has been the training-ground of so many geologists of eminence, Dr. Reusch has zealously pursued the study of our science in his native land. Undeterred by the difficulties which beset the students of its rocks, and avoiding the pitfalls of hypothesis, he has garnered a store of information which is of very high value to the students of the crystalline schists. Nor has he confined his attention to

these rocks, but has added to our knowledge of the glacial phenomena of his country, and of recent years especially has been attracted by the fascinating task of accounting for many of its surface-features.

The reception of the Medal by you, Sir, on Dr. Reusch's behalf but partially diminishes our regret at his absence this day. In conveying the Medal to him, will you at the same time convey the good wishes of the many workers in this country who are glad to number him among their friends.

Sir Archibald Geikie, in reply, said:—

Mr. President,—It gives me great pleasure to be the medium of transmitting the Lyell Medal to my old friend Dr. Hans Reusch. No one who is familiar with the progress of geology in Scandinavia during the last quarter of a century can have the least hesitation in cordially approving the action of the Council in conferring this distinction upon him. He has thrown light on the oldest rocks of Norway and on the problems of metamorphism, and he has included the youngest geological phenomena within his ken. Having had the advantage of making traverses of his ground with him in the north of Norway, I can bear witness to his keen powers of observation, and to the enthusiasm with which he employs them. We may hope that many years of active work are still in store for him, to the great advantage of our science. Dr. Reusch, in asking me to receive the Medal on his behalf, has enclosed a few words of acknowledgment, which I will now read:—

"It is to me a great and unexpected pleasure to receive the Lyell Medal from the Council of a Society so celebrated throughout the scientific world.

"It is the case with me, as with so many others, that the name of Lyell is allied with our earliest interest in the science dear to us all. I remember well, though I have not seen it for a good many years, the old copy of the first German translation of the 'Principles,' borrowed, when I was a boy, from the Museum in my native town of Bergen, and how I read in it with wonder of the evolution of the very earth that we are wandering upon.

"In later years, during the 'seventies,' when I was a student, the stout volumes of the 'Quarterly Journal' in the University Library in Christiania were always of the greatest interest to me, as they appeared year by year; and it was a memorable day of joy to me when the news arrived that I had myself the honour of being elected a Member of the Geological Society.

"My work in the days left to me will be, I hope, in my native land of Norway. As your Society embraces the whole world in its survey of our science, it is my hope that such small sparks of truth as I may be able to add to what is known of the geology of Norway may be of some small interest to your Members. I return my heartiest thanks to the Council of the Geological Society for the great and undeserved honour which they have bestowed upon me."

The President, in presenting the Bigsby Medal to Professor John Walter Gregory, D.Sc., F.R.S., addressed him in the following words:—

Professor Gregory,—The Bigsby Medal is awarded to you, as an acknowledgment of your eminent services to Geology, the result of work carried on in many parts of the world.

The founder of this Medal was himself a traveller. In the preface to his book "The Shoe and Canoe," he tells us that he spent six happy years wandering over the greater portion of the Canadas. He also did good service by his work in the study, as shown by his "Thesaurus Siluricus" and "Thesaurus Devonico-Carboniferous." Could he extend his hand across the gulf, I feel that he would give a warm welcome to one who has earned this award by work in the study and the museum, and by explorations carried out in many lands, exposed at times to the scorching sun of Africa, at others to the icy blast of Arctic climes.

Worthy indeed are you to receive this Medal, which in the terms of the Bequest is to be awarded "as an acknowledgment of eminent services in any department of Geology," for we acknowledge your services in all departments of that science.

Professor Gregory replied as follows:—

Mr. President,—It is impossible adequately to express my thanks to the Council for the honour of this award, and to you, Sir, for the very kind words with which

you have presented it. My only regret in connection with this Medal is that, owing to your many years of devoted service to the Society as its Secretary, your name does not appear on the roll of my predecessors.

The list of my contributions to geological literature includes a somewhat wide range of subjects, to which you have referred very kindly, although they may appear sadly disconnected. Of course, every geologist who is not master of his own time must devote most of his energies to work not of his own selecting. He must do what he should, and not what he would. I owe it to the sympathetic consideration with which the senior officials of the British Museum treat their assistants, that much of my work when I was on its staff had as close a bearing as it had upon the problems in which I have been most deeply interested. My attention was first directed to geology in order to understand the geography of the districts through which I rambled, and the often apparently erratic course of the rivers. The bent that led me into geology, in order to understand local topography, subsequently roused my especial interest in the existing plan of the Earth. That interest has caused me to spend so much of my vacations collecting evidence in the 'back-blocks' of the Earth, that I have not yet had sufficient opportunity to work out the results. This award will justify an attempt to secure more time for this work. One of the favourite proverbs of one of my old Zanzibar porters was 'Whither good things go, thence good things should return.' The words of Bigsby's will show that this maxim inspired his bequest; and I am bound to make as good a return to our science as I can for this valued Medal, and for the good wishes and cheering confidence which it betokens.

In presenting the Balance of the Proceeds of the Wollaston Donation-Fund to Mr. Henry Howe Arnold-Bemrose, M.A., the President addressed him as follows:—

Mr. Arnold-Bemrose,—The Council have awarded the Balance of the Proceeds of the Wollaston Donation-Fund to you, as an acknowledgment of the value of your investigations among the igneous and other rocks and the cave-deposits of Derbyshire.

In the intervals of a busy life you have done much to add to our knowledge of the geology of that county, and have also generously placed your services at the disposal of geologists visiting the district. We look forward with confidence to further work from your pen, and hope that you will receive this award as an encouragement to you in carrying on your labours.

The President then presented the Balance of the Proceeds of the Murchison Geological Fund to Mr. Herbert Lister Bowman, M.A., addressing him in the following words:—

Mr. Bowman,—There appeared at one time to be some danger that Mineralogy might be divorced from Geology. This Society has never ceased to recognize the relationship of the two sciences, and the Council acknowledge it on this occasion by awarding the Balance of the Proceeds of the Murchison Geological Fund to you, who are pursuing the study of the former science. The Council moreover hope that this award may encourage you to prosecute further those researches in which you are already so far advanced,—researches in a science the study of which has received so great an impetus in your University by the labours of the distinguished occupant of the Waynflete Chair of Mineralogy.

The President then presented a moiety of the Balance of the Proceeds of the Lyell Geological Fund to Mr. Edward Alexander Newell Arber, M.A., addressing him as follows:—

Mr. Arber,—The Council have awarded a moiety of the Balance of the Proceeds of the Lyell Geological Fund to you, in recognition of your valuable contributions to our knowledge of Palæobotany.

In addition to the papers which you have contributed to this Society, I would specially refer to the paper on "The Fossil Flora of the Culm-Measures of North-West Devon," printed in the Philosophical Transactions of the Royal Society.

I hope that you will regard this award as an encouragement to further work. Let me assure you of the pleasure which it gives me to hand it to a former pupil and present colleague.

In presenting the other moiety of the Balance of the Proceeds of the Lyell Geological Fund to Mr. Walcot Gibson, B.Sc., the President addressed him as follows :—

Mr. Walcot Gibson.—A moiety of the Balance of the Proceeds of the Lyell Geological Fund is awarded to you as an acknowledgment of the valuable work done by you among the Carboniferous and other strata of the Midland counties, as well as among the auriferous and associated rocks of South Africa, and as an encouragement to further research.

While pursuing your calling as a Geological Surveyor, you have been ever on the alert to utilize what has been written concerning the rocks which you mapped, and also to record your own observations, with results beneficial alike to the Survey and to the science.

The President then proceeded to read his Anniversary Address, giving first of all obituary notices of several Fellows deceased since the last annual meeting, including General C. A. McMahon (elected a Fellow in 1878), Sir Clement Le Neve Foster (el. 1863), Mr. F. Rutley (el. 1870), Mr. R. F. Tomes (el. 1877), Mr. R. H. Valpy (el. 1862), Mr. W. Ferguson (el. 1854), the Rev. H. Brass (el. 1857), Dr. C. Ricketts (el. 1867), Mr. T. W. Shore (el. 1878), the Rev. H. P. Gurney (el. 1877), Mr. F. McClean (el. 1863), Dr. I. Roberts (el. 1870), and Mr. R. M. Browne (el. 1867); also of Professor F. Fouqué (el. For. Memb. 1889) and of Dr. C. E. Beecher (el. For. Corr. 1899).

He then proceeded to call attention to the Classification of the Sedimentary Rocks, pointing out that the arrangement of the events which, taken together, constitute Earth-history, according to their proper sequence in time must ever remain the territory of the geologist in which he will pursue his labours by exclusively geological methods.

He pointed out that, since the time of William Smith, and mainly by the adoption of his principles, the classification of the strata had progressed towards perfection by the method of successive approximations.

He drew attention to the many similarities between the records of the geological column and the records preserved in the 'meteorograms' of meteorologists. In each case the records were impressed as zigzag and broken lines, though an additional difficulty occurred in the case of the geological records owing to their frequently blurred nature.

Further, the meteorologist had his chronometer, whereas the geologist must construct his time-scale from the records on what might, for purposes of comparison, be referred to as the 'geograms,' or strips of the geological sediments. In some cases the lines of the geograms closely coincided with time-lines, in other cases they departed therefrom more or less widely, and it was one of the tasks of the geologists, from study of the geograms, to attempt to draw in the time-lines.

It was to be remembered, however, that however closely the time-lines and lines of the records coincided, they were not the same lines.

The President drew attention to the principal variations in the records of the geograms, due to alternate formation and cessation of

deposit; to the differences in character of the deposits owing to various local conditions; to accumulation of contemporaneous volcanic material; to variations in the nature of the earth-movements; to changes in the nature of the included organisms; and lastly to climatic changes, and proceeded to consider the significance of these records as bearing upon the classification of the sediments.

He advocated the adoption of a triple classification, such as had been already tacitly adopted in the case of some of the sediments, as, for instance, those of Jurassic age, where divisions were made according to (i) lithological change, (ii) organic change, and (iii) time; and pointed out how such a classification could be adopted without any violent changes in an existing nomenclature or in the rules of priority.

He illustrated the suggested changes by a more detailed discussion of the classification of the Ordovician strata, and pointed out that we had names which might be used with chronological significance in the case of the divisions of the rocks of most of the great systems; and maintained that, as our knowledge increased, we could refer beds of new areas to their places among the different series marking periods of time with a confidence similar to that with which we have long assigned strata of remote regions to one or other of the great systems.

The ballot for the Council and Officers was taken, and the following were declared duly elected for the ensuing year:—*Council:* F. A. Bather, M.A., D.Sc.; W. T. Blanford, C.I.E., LL.D., F.R.S.; Professor T. G. Bonney, Sc.D., LL.D., F.R.S., F.S.A.; Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S.; Professor E. J. Garwood, M.A.; Sir Archibald Geikie, Sc.D., D.C.L., LL.D., Sec.R.S.; R. S. Herries, M.A.; Professor J. W. Judd, C.B., LL.D., V.P.R.S.; Professor Percy F. Kendall; Philip Lake, M.A.; Professor Charles Lapworth, M.Sc., LL.D., F.R.S.; Richard Lydekker, B.A., F.R.S.; Bedford McNeill, Assoc.R.S.M.; J. E. Marr, Sc.D., F.R.S.; Professor H. A. Miers, M.A., F.R.S.; H. W. Monckton, F.L.S.; F. W. Rudler, I.S.O.; L. J. Spencer, M.A.; Aubrey Strahan, M.A., F.R.S.; C. Fox Strangways; Professor W. W. Watts, M.A., M.Sc., F.R.S.; the Rev. H. H. Winwood, M.A.; and H. B. Woodward, F.R.S.

Officers:—President: J. E. Marr, Sc.D., F.R.S. *Vice-Presidents:* Professor T. G. Bonney, Sc.D., LL.D., F.R.S., F.S.A.; R. S. Herries, M.A.; Professor Charles Lapworth, M.Sc., LL.D., F.R.S.; and H. B. Woodward, F.R.S. *Secretaries:* Professor E. J. Garwood, M.A., and Professor W. W. Watts, M.A., M.Sc., F.R.S. *Foreign Secretary:* Sir John Evans, K.C.B., D.C.L., LL.D., F.R.S., F.L.S. *Treasurer:* W. T. Blanford, C.I.E., LL.D., F.R.S.

II.—February 22nd, 1905.—J. E. Marr, Sc.D., F.R.S., President, in the Chair.

Dr. F. A. Bather exhibited a series of Danish rocks[1] illustrating:

(1) The share that Echinoderms may take in rock-building;

(2) The transition from the Secondary to the Tertiary Era in the Baltic basin near Denmark;

(3) The special conditions at the close of the Glacial Period, in the limited area where alone these rocks are now found as erratic blocks.

[1] The rocks have been described in papers by K. A. Grönwall: Danmarks geol. Undersög. II, Række, No. 15; Medd. Dansk geol. Foren., vol. x, p. 1; and Jahrb. Preuss. geol. Landesanst., vol. xxiv, p. 420—all in 1904. Also by W. Deecke, Mitth. naturwissench. Ver. Neuvorpommern, vol. xxxi (1899), p. 67.

The specimens comprised:— (*a*) Fragment of a boulder from the Free Harbour of Copenhagen, consisting of rock from the zone of *Crania tuberculata*, and containing many unrolled echinoderm fragments; it appears to have been formed in shallow water; (*b*) fragment of a boulder from Langeland, consisting of rock of Palæocene age, and containing rolled fragments of Cretaceous echinoderms with shells of Tertiary molluscs; (*c*) fragment of a similar boulder, showing signs of further detrition; (*d*) fragment of a boulder from the island of Rügen, with echinoderm fragments still more rolled. All these rocks appear, from the distribution of the boulders, to have been deposited in a basin of the Baltic between Scania and the islands of Rügen and Bornholm, where the Palæocene sea was shallower than on the west of Denmark.

The following communications were read:—

1. "On the Order of Succession of the Manx Slates in their Northern Half, and its Bearing on the Origin of the Schistose Breccia associated therewith." By the Rev. John Frederick Blake, M.A., F.G.S.

The author first describes a section where the Barrule Slate, the Snaefell Laminated Slate, and the Agneash Grit follow in descending order, dipping north-westward. The last-named is markedly laminated. The ascending series, by dip, is again repeated after a fault, and at Tholt-y-will the Schistose Breccia appears near or at the top. The best sections of the latter for stratigraphy are in Glen Auldyn and Sulby Glen. The Schistose Breccia is therefore taken as an additional upper member of the series.

General Distribution of the Manx Slates.—The Agneash Grit in Maughold Head is nearly vertical, and is followed by the Snaefell Laminated Slates. The height to which the Barrule Slates attain diminishes from east to west. The Schistose Breccia depends on the presence of those slates; its occurrence is noted in four areas to the west of the Barrule Slates, which are repeated by faults.

The position of the Lonan and Niarbyl Flags is indicated by two colours on the map. The Lonan Flags, etc., are never seen underlying the Manx Slates, but they overlie the earlier Manx Slates in the lower country near Maughold, near Sulby Glen, and north of Peel. They may, therefore, be called the Sulby Glen Series.

Characters and Origin of the Schistose Breccia.—Professor C. R. Van Hise gives three criteria for autoclastic rocks, with none of which do the Schistose Breccias agree, namely, the fragments of an autoclastic rock must be derived from the adjacent material; whether they be below or above; and the rock itself may be traced into an ordinary brecciated rock. The fragments examined do not agree with this statement. The rocks are not truly conglomeratic—some are too soft, or others too hard.

Examples at Ballaneary and elsewhere occur, of true autoclastic rocks, showing contrast.

2. "On the Wash-outs in the Middle Coal-measures of South Yorkshire." By Francis Edward Middleton, F.G.S.

In the neighbourhood of Aldwarke and Thrybergh extensive workings have proved that wash-outs have occurred at various horizons in the Middle and Lower Coal-measures, and the limits of certain of these have been accurately laid down on plans.

Denudation in the Barnsley Seam has been found over an area 1,700 yards in length from east to west, and in the Parkgate Seam (240 yards below) over an area 2,600 yards long from north to south. In neither case was the wash-out completely crossed, but its width cannot be less than 600 yards. The Swallow-Wood Seam, lying 60 yards below the Barnsley and above the Parkgate Seam, has been partly worked under the same area; but no signs of a wash-out have been found.

The opinion of the author is that the wash-outs occupy the sites of winding streams, meandering through the alluvial tracts in which the coal-seams were being formed.

CORRESPONDENCE.

FIVE THEORIES OF THE DEVON SCHISTS.

Sir,—Your reviewer has perhaps been unduly, and doubtless unintentionally, severe on the whole army of martyrs who have sacrificed themselves on the altar of the Devonshire schists during the past sixty-eight years. He hopes that mere hypothesis will soon give way to a more reasonable and probable interpretation of the facts. But, in truth, there has been but little hypothesis; though we undoubtedly have several elaborate theories, based on evidence much of which has seemed to eminent men worth consideration. We have had, for instance, the following distinct lines of argument:—

1. The schists are Upper Devonian, based on a certain interpretation of the anticline at Mudstone Bay, near Berry Head, and other stratigraphical facts.

2. The schists are Archæan, based on elaborate microscopical observations backed by great experience.

3. The schists are Devonian, based on a comparison of the slates, sandstones, and volcanic rocks between Scabbacombe Sands and Stoke Fleming with the schists between Hall Sands and the Prawle Point.

4. The Start schists are Lower Devonian, based on a comparison of the microscopical composition, character, and fineness of grain of the quartz-schists with those of the Lower Devonian thin-bedded sandstones.

5. The schists are older than Devonian, but not necessarily Archæan. The positive arguments in favour of this view I do not fully grasp.

Curiously enough, the authors of the Memoir, in their list of literature, have missed a most important paper, viz. "The Metamorphosis of the Rocks extending from Hope Cove to Start Bay," by W. Pengelly, F.R.S. (Trans. Dev. Assoc., 1879). This paper is very important as a summary of the current opinions then held by geologists. The Upper Devonian age of the schists was treated as

an almost trustworthy working hypothesis from which to deduce the 'era of transformation.'

No doubt the earlier geologists misinterpreted the stratigraphy of South Devon, and therefore their theory broke down; but it was a very elaborately argued theory, and was by no means a hypothesis.

The Archæan doctrine of the schists is also a true theory, based on innumerable observations.

Mr. Somervail's view (No. 3) inferred the contemporaneity of the schists with the Scabbacombe–Stoke Fleming rocks; but the age of the schists will follow the age determined for the said rocks. There is nothing approaching a hypothesis in the argument.

No. 4, for which I am responsible, is based on a study of sediments, and is independent of both petrology and stratigraphy. It was at first based on a comparison of two specimens of thin-bedded sandstones with a specimen of a quartz-schist west of the Start. I first advanced it in a paper to the British Association in 1891; contending that the sandstone being Devonian the schist was Devonian too. This, however, committed me to it being also Lower Devonian.

In its then early stage this view was no more than a working hypothesis, advanced before the Survey attacked the schist district on its own account. It was a friendly challenge to my friends to upset me if they could. But, strange to say, they never succeeded in doing so, neither stratigraphically nor petrologically. My view has now attained the unexpected dignity of a theory, and has actually survived fifteen years' hostile criticism, and the accumulation of an immense mass of fresh information. However, it was never a mere hypothesis, as the facts, though few, were undoubted.

Until the publication of the Memoir there was one very weak spot in my armour. I had entirely failed to trace the albite granules of the schists into the Devonian rocks. Now that the quartz-felspar veins, abundant in both series, have been proved to be quartz-albite, that missing link is unexpectedly connected.

The view No. 5 was first advanced by Mr. Hudleston, F.R.S., in his address to the Devon Association, and has since been adopted by Mr. Lowe, F.G.S., and is apparently accepted by your reviewer. It is equally subversive of all the others, whether based on petrology, stratigraphy, or sediments. My contention that Nature will never exactly reproduce in the same spot Archæan conditions in Devonian times, is almost equally cogent against her reproducing Cambrian or Silurian conditions. As my argument is that the rocks in question (the quartz-schists) are Lower Devonian, and is not that these rocks are not Archæan, Cambrian, or Silurian, any of these latter alternatives is equally fatal to theory No. 4. Were I to be ousted from No. 4 I should return to my former allegiance to Professor Bonney. However, during the past fifteen years I have not been favoured with a scrap of evidence against my Devonian theory from the sediment point of view, and, so far as I can ascertain, there is no petrological or stratigraphical fact in hopeless conflict with it.

There is one point I may perhaps mention. Although the Torcross volcanic rocks are very inconsiderable, the Scabbacombe–Stoke

Fleming rocks are very important, both on shore and at sea. The islets of the Mewstone, Eastern Blackstone, and Western Blackstone are all volcanic. The Mewstone, with its southern mass of diabase abutting on its northern vertical slates, is as like the green 'schist' and mica-schist at the Start as a raw egg is to a boiled one; and I fully believe their relations are very similar thereto. A. R. Hunt.

CAVITIES IN CRYSTALLINE ROCKS.

Sir,—I notice in the February number of the Geological Magazine a letter from Professor Bonney on the subject of atmospherically eroded rocks. In this connection it may be of interest to put on record the fact that hollowed rocks, apparently quite like those described by Mr. Tuckett, Professor Bonney, and the Rev. R. Baron, were met with under totally different atmospheric conditions in the Antarctic. The examples there also occur in granite. They are found at an altitude of about 4,000 feet in latitude 77° 49′ S., longitude 163° E., in South Victoria Land, and at least two types may be distinguished.

A. In fairly normal granite. The rock is a very ordinary grey to pink granite with felspars usually about a quarter of an inch long; it appears to be quite fresh even on the surface, and has a marked superficial glaze on both convex and concave surfaces. The most striking cavity is on the south and weather side of a large block, and therefore faces away from the sun; it is about eighteen inches across

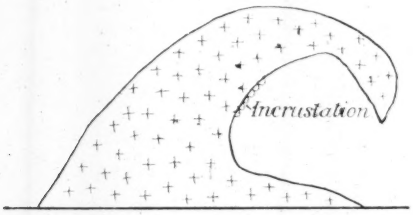


Fig. 1.—A large block of granite showing cavity on the south and weather side; 18 inches across at opening, diameter increasing to 2 feet inwards; depth of cavity more than a foot.

at the opening, and the diameter increases inwards to at least two feet. The depth of the cavity is a little more than a foot, and the back wall is partially covered with a hard mammillated or botryoidal crust, the surface of which is white and harsh to the touch. Pieces of this were brought home, and some of these Mr. Prior has kindly analysed for me: he says, "the incrustation consists mainly of carbonate of lime; there is a little silica left behind on solution in hydrochloric acid." The incrustation was lamellar, scarcely more than one-eighth of an inch thick on the average, but in the projecting botryoids, which are sometimes partially hollow, may be more. The incrustation was firmly fixed to the granite face, and it was impossible to make out whether the surface beneath it was or was not glazed.

B. In a very coarse granite with abundant large crystals of orthoclase. The hollowed blocks are rounded, but owing to the

rapid disintegration which the surface is undergoing it is roughened rather than glazed. The largest cavity is in a block 6 by 4 by 4 feet, which is hollowed almost to a shell. The cavity is four feet long, three feet deep, and two feet high, and has four apertures varying from a foot to eighteen inches in diameter, and corresponding

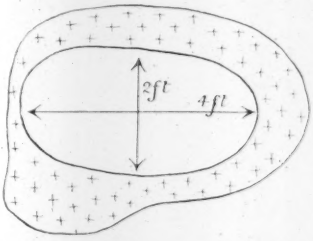


Fig. 2.—Cavity in a block of very coarse granite, 6 × 4 × 4 feet. The cavity is 4 feet long, 3 feet deep, and 2 feet high, and has four apertures varying from a foot to 18 inches in diameter, one on each side of block.

in position to the centre points of the four sides of the original block. The lip of the apertures is exceedingly sharp, and the solid angle is certainly not greater than 30°. No incrustation was seen on the walls of this cavity, but on the floor is a sprinkling of the finer disintegration products of the granite which abundantly litter the surrounding area.

From this brief description it will be seen that the former type of Antarctic granite cavities closely resembles in shape and in superficial glaze the cavities described in Corsica and in Madagascar. As in Corsica, many saucer-like depressions and a few potholes were observed, and seem to mark stages in the development of the completed cavities. Internal incrustations do not seem to be recorded, but Mr. Baron mentions a "white powder alkaline to the taste" as occurring in the hollowed blocks of Madagascar.

Sidney Sussex College, Cambridge. H. T. Ferrar.
February 18th, 1905.

THE PROSPECTORS' PAN.

Sir,—May I be allowed to point out the advantages to be derived by the use of the prospector's pan as an aid to research in geology? Everyone interested in the subject is, of course, aware that minerals of economic importance may be traced to their original sites by successive pannings taken from the alluvium of a stream at points successively nearer to the source, due attention being paid to the incoming of tributaries; but the method is not in common use by the geologist.

The gold pan treats some 25 lbs. of medium gravel, containing small boulders, at one time, and the operation of panning can of course be stopped at any stage desired so as to include or exclude such minerals as tourmaline and hornblende. I would suggest that for investigations into the mineralogical composition of glacial deposits and the more compacted sediments this method of panning might be tried. In dealing with a hard rock, pounding in a mortar

and the proper use of sieves of various meshes may be necessary before panning. The method is rapid, gives reliable quantitative results, and deals with larger quantities than are convenient by more refined means.

Pan concentrates derived from any given crystalline rock become readily recognizable after a short time, and in forested country, where little or no rock is visible, afford a valuable guide in rough mapping. That, at least, is my experience in Southern Nigeria.

CALABAR, W.C.A. JOHN PARKINSON.
January, 1905.

OBITUARY.

JEREMIAH SLADE, F.G.S.

BORN JULY 19, 1828. DIED MARCH 9, 1905.

IT is with much regret that we record the death, at the age of 76, of Mr. J. Slade. Although not known to scientific workers by published researches he had for half a century been a strenuous teacher and a helper to others. Brought up to the business of a coachbuilder in St. John Street Road, London, he was enabled comparatively early in life to retire, and devote his whole attention to natural history. While resident in the north of London he was a supporter of the once flourishing Literary and Philosophical Institution in Islington, and a frequent attendant at Dr. Bowerbank's "Monday Evenings at home" in Highbury Grove. He was early connected with the Working Men's College in Great Ormond Street, and it was at that institution in 1858 that the formation of the Geologists' Association was first discussed. Among those who took part in the provisional committee and who became founders of the Association were the Rev. T. Wiltshire, Mr. George Potter, Mr. Toulmin Smith, Mr. E. Cresy, Mr. W. Hislop, Mr. J. E. Wakefield, Mr. G. S. Penson, and Mr. J. Slade. In 1866 Mr. Slade assisted in the formation of the North London Naturalists' Club, the earliest field-club devoted to the study of natural history in the neighbourhood of London, and of which he was chosen Secretary. For twenty years (1865–85) he was a teacher of geology, mineralogy, zoology, and botany at the Working Men's College, the Birkbeck Institution, and the City of London College. During this period, from 1870 to 1875, he studied at the Royal School of Mines. He was an active member of the Quekett Microscopical Club, and he became a Fellow of the Geological Society in 1874. A constant attendant at the excursions of the Geologists' Association, his extensive and accurate information on many subjects, and his knowledge of plants especially, were ever cheerfully and unostentatiously communicated to inquiring students. The only printed paper contributed by him to the Association was entitled "Notes on the Microscopic Structure of the Basalt of Swallow Cliff and Uphill" (Proc. Geol. Assoc., vol. vii, 1881, pp. 112, 113). His services to science are not recorded on paper, but they have borne good fruit and will long be remembered by a circle of friends whose love of Nature has been inspired and cultivated by his disinterested labours. H. B. W.